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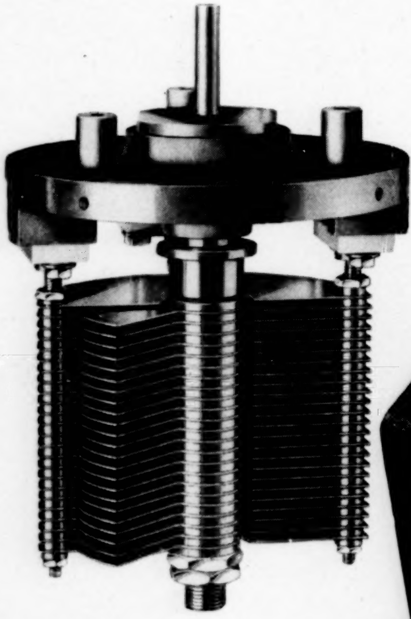

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THE
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Editorial

The Twin-T Method of Measuring Coil Constants

In our editorial article of April, 1941, we discussed the bridged-*T* method of measuring the constants of a coil. We had previously discussed the use of the same circuit for measuring high resistances. Our attention has recently been drawn to an interesting extension of the circuit which has been developed by the General Radio Company of America and incorporated in a commercial instrument covering a frequency range from 0.5 to 30 megacycles per second. It is claimed* that the upper frequency limit at which precise measurements can be made by null methods has thereby been extended greatly beyond the limit commonly found in commercial radio-frequency bridges.

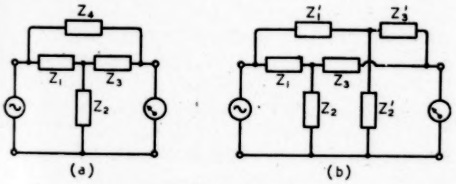

Fig. 1.

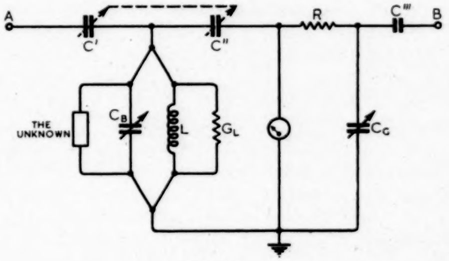

Fig. 2.

The bridged-*T* is shown in Fig. 1a, the twin-*T* or parallel-*T* in Fig. 1b; in the former there are four elements, in the latter six; if Z_2' is made infinitely large the latter reduces to the former. In Fig. 2 the two *T*'s are shown side by side, with the detector between them; the points *A* and *B* are joined together to one terminal of the generator, the other terminal being earthed. The unknown impedance in parallel with the variable condenser C_B and the coil *L* forms the vertical limb of the left-hand *T*. The variable condenser C_G forms the vertical limb of the right-hand *T*. When balanced, the detector could be short-circuited or regarded as carrying two equal and opposite currents: one equal to V_1 divided by the transfer impedance of the left-hand *T*, and the other equal to V_1 divided by the transfer impedance of the right-hand *T*, where V_1 is the applied voltage. Hence the condition of balance is that the two *T*'s should have equal and opposite transfer impedances. In Fig. 1b the condition for this is that

---

* Bridged-*T* and Parallel-*T* circuits. W. N. Tuttle. *Proc. Inst. Rad. Eng.*, Jan., 1940. The Twin-*T*, etc. D. B. Sinclair. *Proc. Inst. Rad. Eng.*, July, 1940.

$$Z_1 + Z_3 + \frac{Z_1 Z_3}{Z_2} + Z_1' + Z_3' + \frac{Z_1' Z_3'}{Z_2'} = 0$$

Substituting the values of the components in Fig. 2 we obtain in the absence of the unknown impedance,

$$G_L = R\omega^2 C'C''\left(1 + \frac{C_G}{C'''}\right)$$

and $$C_B = \frac{1}{\omega^2 L} - C'C''\left(\frac{1}{C'} + \frac{1}{C''} + \frac{1}{C'''}\right)$$

On connecting the coil under test, balance is restored by readjusting the two variable condensers C_B and C_G. If the coil has an admittance $G_X + jB_X$ we can write

$$G_X = \frac{R\omega^2 C'C''}{C'''}\left(C_{G_2} - C_{G_1}\right)$$

and $$B_X = \omega(C_{B_1} - C_{B_2})$$

The two are seen to be independent of each other, but they are not independent of the frequency, the former varying as the square of the frequency.

It is a great advantage that so many elements of the circuit have one terminal earthed, thus avoiding much of the necessity for shielding; also many of the residual capacitances cancel out when adopting the method outlined above, which is partially a substitution method. Another advantage is that the conductive component is measured by a fixed resistor and a variable condenser, thus avoiding the troubles associated with a variable resistor at these high frequencies. The variable condenser C_B has only a limited range and this must be extended by switching in various values of the inductance L; a parallel condenser enables C_B to be adjusted to a convenient part of the scale before connecting the coil under test. The condenser C_G is also provided with an auxiliary trimmer condenser. Since, as we saw above, G_X varies as $\omega^2 C'C''$ for a given range of C_G, it is necessary to decrease C' and C'' at high frequencies. They are not continuously variable, as indicated in Fig. 2, but can be switched to four different values from 10 to 54 $\mu\mu$F, C''' being kept constant at 3 $\mu\mu$F.

Some idea of the difficulties of design can be formed from the fact that the inductance of an inch of wire may cause serious error. The leads between the condensers $C'C''$ and C''' and the resistor R, shown as AB in Fig. 2, are of copper strip and are all made less than an inch long. For the same reason the condensers C_B and C_G are as close as possible to the junctions between C' and C'' and between R and C''' respectively. Another cause of error at these very high frequencies is the inductance of the condensers; if the current is led in and out of the condenser in the usual way this error may be quite considerable. This has been overcome to a large extent in the important case of C_B by feeding both stator and rotor symmetrically at several points. In the article by Sinclair there are a number of photographs showing details of construction, and also a very full investigation of the effects of the various unavoidable residual inductances, resistances and capacitances, and the methods whereby these effects have been eliminated or made negligible up to a frequency of 30 megacycles per second.

G. W. O. H.

INDEX to ABSTRACTS

Must be ordered in advance

FOR several years past *The Wireless Engineer* has published, with the December issue, a subject index to the Abstracts and References section.

The inclusion of this Index as a part of the December number will be discontinued this year, and instead, this Index, incorporating also an Index to Authors, will be published separately, early in 1942.

The December number, therefore, instead of being largely devoted to this Index, will be a normal issue including the Abstracts and References Section which has formerly been omitted to make place for the Index.

A charge of 2s. 6d. will be made for the separate Index, and it will be necessary that those requiring copies should make application for them to the Publishers before the end of the year, as otherwise it will not be possible to guarantee that copies will be available.

Anode Dissipation in Anode-Modulated Class C Amplifiers*

By R. G. Mitchell, B.Sc.

(Communication from the Research Staff of the M.O. Valve Co., Ltd., at the G.E.C. Research Laboratories, England).

SUMMARY.—The effect on anode dissipation of anode modulation is investigated, theoretically and also by practical tests. Formulae are developed to facilitate the assessment of the anode dissipation for any depth of modulation. The effect of non-linearity of the amplifier is discussed.

An analysis is given showing how the input is distributed between the H.T. and modulator sources.

1. Introduction

It is customary in anode-modulated Class C amplifier operation to limit the anode dissipation in the carrier condition to 2/3 of the maximum permissible for other modes of operation. The reason is that, assuming constant efficiency over the audio cycle, the average input and output on 100 per cent. modulation increase to 1.5 times their values in the carrier condition, so that the anode dissipation also increases by the same factor. The result is that on 100 per cent. modulation the maximum permissible anode dissipation is attained.

The assumption as to constant efficiency is, however, only true when elaborate compensation is provided in the driver stage, which is seldom the case, otherwise the anode dissipation is greater than if the constant efficiency assumption were true. In this article a formula is developed to enable the ratio of average dissipation to carrier dissipation to be calculated from certain predetermined factors for any given average depth of modulation. The permissible carrier anode dissipation can then be assessed.

The effect is discussed in an article by Mouromtseff and Kozanowski (*Proc. Inst. Rad. Eng.*, 1935), who verified by practical tests that the anode dissipation increases by more than 4/1 in the crest of the audio cycle with 100 per cent. modulation, which means a larger ratio than 1.5 of average dissipation to carrier dissipation. The authors do not, however, give any mathematical analyses and deal solely with the effect at the crest of the audio cycle with 100 per cent. modulation.

As such amplifiers are seldom linear, it might be supposed that the excess is due to non-linearity. That this conclusion is erroneous is shown in this article. Not only is the increase obtained when the amplifier is perfectly linear, but departure from linearity has only a small effect on the average anode dissipation.

2. List of Symbols Employed

Ea = Mean D.C. anode voltage.
$\hat{e}a$ = Peak H.F. anode voltage swing.
Ia = D.C. anode current.
$\hat{i}a$ = Peak anode current.
$\hat{i}p$ = Peak of fundamental component of anode current.
Eg = D.C. grid bias voltage.
$\hat{e}g$ = Peak grid voltage swing.
eg_m = Maximum positive grid voltage $= (\hat{e}g - Eg)$.
D = Anode dissipation.
θ = Half angle of anode current flow per cycle.
θ/π = Fraction of H.F. cycle during which anode current flows.
$x = 1 - \cos\theta$.
$h = \hat{e}a/Ea$.
Zo = Anode load impedance.
M = Modulation depth.
$\phi = 2\pi pt$ where p is frequency of modulation.
η = Efficiency.
wi = Input.
$w\mu$ = Output.
Fwi = Input factor, where input $= Ea.\hat{i}a.Fwi$.
$Fw\mu$ = Output factor, where output $= \hat{e}a.\hat{i}a.Fw\mu$.

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* MS. accepted by the Editor, June, 1941.

$F\eta$ = Efficiency factor, where efficiency $= h.F\eta$.
gm = Mutual conductance.
μ = Amplification factor.

(Fwi, $Fw\mu$ and $F\eta$ are all functions of θ).

The suffix $_c$ to any of the above symbols denotes application to the carrier, and suffix $_t$ to the crest of the audio cycle with 100 per cent. modulation.

The following relationships should be noted :—

$Ia = \hat{\imath}a \,.\, Fwi$ $F\eta = Fw\mu/Fwi$

$Ia.F\eta = \hat{\imath}a \,.\, Fw\mu$ $x = \dfrac{\hat{\imath}a}{gm(\hat{e}g - \hat{e}a/\mu)}$

$\hat{\imath}p = 2Ia \,.\, F\eta$ $\eta = h \,.\, F\eta$

3. Assessment of Anode Dissipation assuming Linearity of Output

The fallacy of the 3/2 relationship in respect of non-compensated amplifiers can be simply shown by the following reasoning.

As there is no compensation, $\hat{e}g$ must be constant over the cycle of modulation, and as $\hat{\imath}a$ and $\hat{e}a$ must increase as the crest is approached, then x, which equals $\hat{\imath}a/gm$ $(\hat{e}g - \hat{e}a/\mu)$ must increase proportionally. This means that θ increases, which means lower efficiency.

In practice it is found that for linearity of output in non-compensated amplifiers, θ/π should vary between about 0.35 in the carrier, and 0.5 in the crest, with 100 per cent. modulation.

For any given case there are no exclusively correct values for θ/π_c and θ/π_t, but they are interdependent, and it is convenient to start calculations by assuming one of the values given above and to calculate the other, as shown in section 5. Usually θ/π_t is assumed equal to 0.5 and θ/π_c calculated.

A formula can be developed to enable the actual anode dissipation to be calculated for any depth of modulation provided that θ/π_t and θ/π_c are predetermined.

Consider an arbitrary point y on the audio cycle of modulation. Then $Ea_y = Ea_c$ $(1 + M \sin\phi)$ where $\phi = 2\pi p t_y$.

Output at point $y = \hat{e}a_y^2/2Zo$.

Carrier output $= \hat{e}a_c^2/2Zo$.

Now for linearity $\hat{e}a_y = \hat{e}a_c\ (1 + M \sin\phi)$

$\therefore$ Output at y = carrier output $(1 + M \sin\phi)^2$.

Also carrier output $= \hat{e}a_c.\hat{\imath}a_c.Fw\mu_c = h.Ea_c.Ia_c.F\eta_c$.

$\therefore$ Output at $y = Ea_c.Ia_c.h.F\eta_c(1 + M \sin\phi)^2$.

Input at point $y = Ea_c(1 + M \sin\phi)Ia_y$.

Now $Ia_y = \hat{\imath}p_y/2F\eta_y$

and $\hat{\imath}p_y = \hat{\imath}p_c(1 + M \sin\phi)$

as $\hat{e}a_y = \hat{e}a_c\ (1 + M \sin\phi)$,

and Zo is constant.

$$\therefore Ia_y = \tfrac{1}{2}F\eta_y(1 + M \sin\phi).\hat{\imath}p_c$$
$$= Ia_c.F\eta_c/F\eta_y(1 + M \sin\phi).$$

Hence input at $y = Ea_c.Ia_c.F\eta_c/F\eta_y(1 + M \sin\phi)^2$.

$\therefore$ Anode dissipation $= D_y$
$$= Ea_c.Ia_c.F\eta_c(1 + M \sin\phi)^2(1/F\eta_y - h)$$

N.B. as $\hat{e}a_y = \hat{e}a_c(1 + M \sin\phi)$, $h(= \hat{e}a/Ea)$ is constant.

$$\text{Then } D_y = Ea_c.Ia_c.F\eta_c(1 + M \sin\phi)^2 \left[\frac{1 - h.F\eta_y}{F\eta_y}\right]$$

If $\dfrac{1 - h.F\eta}{F\eta}$ is plotted against θ/π it can be shown to be practically coincident over the whole range with the curve $1.06\ (\theta/\pi)^2 + c$ where $c = 1 - h$, and this may be substituted in the formula, i.e.

$$D_y = Ea_c.Ia_c.F\eta_c(1 + M \sin\phi)^2 \; (1.06\ \theta/\pi_y^2 + c)$$

The carrier anode dissipation $= Ea_c.Ia_c$ $(1 - h.F\eta_c)$.

$$\therefore D_y = D_c \frac{F\eta_c}{1 - h.F\eta_c}(1 + M \sin\phi)^2 \; (1.06\ \theta/\pi_y^2 + c).$$

The assumption is now made that θ/π varies directly with Ea so that

$$\theta\pi_y = \theta\pi_c + (\theta/\pi_t - \theta/\pi_c)\ M \sin\phi$$

This assumption may not be strictly correct when the trough of the audio cycle is approached on very deep modulation, but any slight error is negligible as the losses are very small in this region.

Substituting for θ/π_y we obtain :—

$$\begin{aligned} D_y = D_cQ(1 + M \sin\phi)^2[c &+ 1.06\ \theta/\pi_c^2 \\ &+ 2.12\ M \sin\phi\,\theta/\pi_c(\theta/\pi_t - \theta/\pi_c) \\ &+ 1.06\ M^2 \sin^2\phi(\theta/\pi_t - \theta/\pi_c)^2] \end{aligned}$$

$$\text{where } Q = \frac{F\eta_c}{1 - h.F\eta_c}$$

and may be obtained from Fig. 5.

The average losses D_v over an audio cycle can now be obtained by integration, i.e.

$$D_v = D_c Q 1/\pi \int_{-\pi/2}^{+\pi/2} (1 + 2M \sin\phi + M^2 \sin^2\phi)$$

$$[c + 1.06\, \theta/\pi_c^2 + 2.12\, M \sin\phi\, \theta/\pi_c(\theta/\pi_t - \theta/\pi_c) + 1.06\, M^2 \sin^2\phi(\theta/\pi_t - \theta/\pi_c)^2]d\phi$$

Ignoring odd powers of sin θ in the product of the integral which cancel out over an audio cycle, we have,

$$D_v = D_c Q 1/\pi \int_{-\pi/2}^{+\pi 2} [c + 1.06\ \theta/\pi_c^2 + M^2 \sin^2\phi \, (1.06\,(\theta/\pi_t - \theta/\pi_c)^2 + 4.24\, \theta/\pi_c(\theta/\pi_t - \theta/\pi_c) + 1.06\, \theta/\pi_c^2 + c) + 1.06\, M^4 \sin^4\phi\, (\theta/\pi_t - \theta/\pi_c)^2]d\phi$$

$$= D_c Q 1/\pi \int_{-\pi/2}^{+\pi/2} [c + 1.06\ \theta/\pi_c^2 + M^2 \sin^2\phi\, (1.06\, \theta/\pi_t^2 + 2.12\, \theta/\pi_t \theta/\pi_c - 2.12\, \theta/\pi_c^2 + c) + 1.06\, M^4 \sin^4\phi\, (\theta/\pi_t - \theta/\pi_c)^2]d\phi$$

$$\doteqdot D_c Q\, [(c + 1.06\, \theta/\pi_c^2) + M^2(c/2 + 0.53\, (\theta/\pi_t + 2.73\, \theta/\pi_c)\, (\theta/\pi_t - 0.73\, \theta/\pi_c) + 0.4\, M^4(\theta/\pi_t - \theta/\pi_c)^2].$$

When $M = 1$ this becomes

$$D_v = D_c Q[3c/2 + 0.93\, \theta/\pi_t(\theta/\pi_t + 0.28\, \theta/\pi_c) + 0.4\, \theta/\pi_c^2]$$

Then if $\theta/\pi_t = 0.5$, $\theta/\pi_c = 0.35$ and $h = 0.8$ we obtain,

$$D_v = 1.92\, D_c$$

and if $h = 0.85$, $D_v = 1.98\, D_c$.

Assuming θ/π_t and θ/π_c equal to 0.5 and 0.35 respectively, we obtain

$$D_v = D_c Q[0.129 + c(1 + M^2/2) + 0.189\, M^2 + 0.01\, M^4].$$

The effect of variation in the value of θ/π_t required for linearity for 100 per cent. modulation, is shown in Fig. 1. It is interesting that if $\theta/\pi_t < \theta/\pi_c$ the ratio of average to carrier dissipation is less than 1.5. This, however, could only happen in an overcompensated amplifier when the crest efficiency exceeds that in the carrier.

When comparing the curve for $\theta/\pi_c = 0.3$ with that for $\theta/\pi_c = 0.35$, it must be remembered that in the former case θ/π_t will be smaller, e.g. about 0.42 as against 0.5. It is thus seen that the ratio is less with the smaller value of θ/π_c. Reduction of θ/π_c in addition to reducing the ratio of average to carrier dissipation, will also, by reason of the improved carrier efficiency, reduce the absolute value of the carrier dissipation. This cannot, however, be reduced too far on account of the greatly increased drive required, and also on account of possible distortion in the trough on high modulation depths.

The effect of variation of the value of θ/π_c required for linearity, assuming $\theta/\pi_t = 0.5$ is shown for 100 per cent. modulation in Fig. 2.

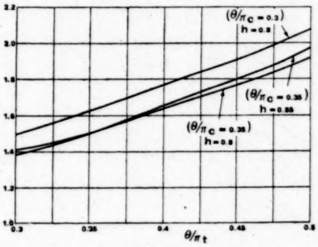

Fig. 1.

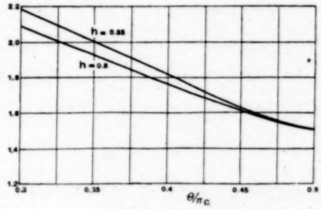

Fig. 2.

Curves showing ratio of anode dissipation on 100 *per cent. modulation to carrier anode dissipation in a linear anode-modulated amplifier.* Fig. 1. *Effect of variation of the value of* θ/π_t *required for linearity.* Fig. 2. *Effect of variation of the value of* θ/π_c *required for linearity when* $\theta/\pi_t = 0.5$.

The effect of variation of modulation depth is shown for the case of $\theta/\pi_t = 0.5$ and $\theta/\pi_c = 0.35$, in Fig. 3. It is seen that the ratio 1.5 is reached on about 70 per cent. modulation, depending on the value of h. It is interesting that, given θ/π_t and θ/π_c, the ratio for any modulation depth is greater for high values of h. The reduction in the absolute value of the carrier dissipation due to the rise in efficiency for a given increase in h, will, however, more than compensate for the resultant increase in the ratio on modulation.

4. Experimental Verification

Practical tests were made to verify this theory, an A.C.T.6 type valve being used. This valve is a triode having a copper anode which forms part of the envelope, and to which an aluminium radiator is fitted. The anode dissipation was measured by means of a thermopile placed close to the anode. This was calibrated by running the valve under static conditions. It was expected from previous knowledge of the characteristics of this type of valve that good linearity would be obtained.

In order to ensure stability, the valve was neutralised and the tests made at a frequency of 3,000 kc/s.

A series of readings were taken for different modulation depths after the valve had been adjusted to its normal carrier operating conditions. The results are shown in the table, and are plotted along with the theoretical curves in Fig. 2.

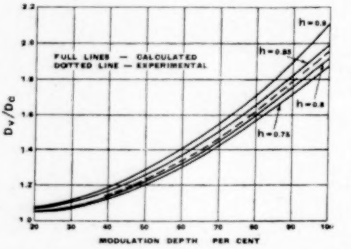

Fig. 3.—*Curves showing effect of variation of modulation depth on anode dissipation in a linear anode-modulated amplifier.*
$\theta/\pi_c = 0.35,\ \theta/\pi_t = 0.5.$

It is seen that the practical result agrees very well with the theoretical, being between the curves assuming h equal to 0.85 and 0.8 respectively. A second test under slightly different conditions of drive gave a curve almost coincident with the theoretical assuming $h = 0.8$.

5. Assessment of θ/π_c

The relationship between θ/π_t and θ/π_c may be derived as follows :—

At any point on the modulation cycle the output

$$w\mu = \hat{e}a.\hat{\imath}a.Fw\mu$$

$$\therefore\ \hat{\imath}a = \frac{w\mu}{\hat{e}a.Fw\mu}$$

$$\text{now}\quad \hat{\imath}a = x.gm(\hat{e}g - \hat{e}a/\mu)$$

$$\therefore\ \frac{w\mu}{\hat{e}a\ .\ Fw\mu} = x.gm(\hat{e}g - \hat{e}a/\mu)$$

$$\text{i.e.}\quad x\ .\ Fw\mu = \frac{w\mu}{\hat{e}a.gm(\hat{e}g - \hat{e}a/\mu)}$$

$x\ .\ Fw\mu$ is solely a function of θ and is designated F.

$$\text{Thus } F_c/F_t = \frac{w\mu_c}{\hat{e}a_c.gm_c(\hat{e}g - \hat{e}a_c/\mu)}$$

$$.\ \frac{\hat{e}a_t.gm_t(\hat{e}g - \hat{e}a_t/\mu)}{w\mu_t}$$

$$\text{and as}\quad w\mu_t = 4w\mu_c$$

$$\text{and}\quad \hat{e}a_t = 2\hat{e}a_c$$

$$\text{then}\quad F_c = F_t/2\,\frac{gm_t(\hat{e}g - \hat{e}a_t/\mu)}{gm_c(\hat{e}g - \hat{e}a_c/\mu)}$$

Then if θ/π_t is assumed, F_t is known, and $\hat{e}g$ and $\hat{e}a_t$ can be calculated. gm_t and gm_c are the average values of mutual conductance at the crest and carrier "buffer" anode voltages, i.e. $Ea(1 - h)$, respectively, and are not necessarily equal. Thus F_c may be calculated, and θ/π_c obtained from curves of F against θ/π given in Fig. 4.

6. Effect on Input and Modulation Power

Assuming linearity of output, the increased losses must result in the input being greater than that calculated on the basis of constant

Percentage modulation	Anode current (mA)	Observed output (watts)	Theoretical output for linearity (watts)	Observed anode dissipation (watts)	Anode Dissipation / Carrier anode dissipation	Total input = total output + dissipation (watts)	H.F. Input *Ea Ia* (watts)	Input from modulator (watts)
0 (Carrier)	100	74	—	26	—	100	100	0
35	100	81	79	29	1.11	110	100	10
50	101	86	83.5	32	1.23	118	101	17
60	102	90	87	35	1.35	125	102	23
70	102.5	94	92	38	1.46	132	102.5	29.5
80	103.5	100	97.5	42	1.62	142	103.5	38.5
90	104.5	105	104	46.5	1.79	151.5	104.5	46.5
100	105.5	110	111	51	1.96	161	105.5	55.5

efficiency. Then as the supply voltage Ea is constant, Ia must increase to a certain extent on modulation. The input from the modulating transformer will also increase, and the following analysis shows in what proportion these two power sources share the excess input.

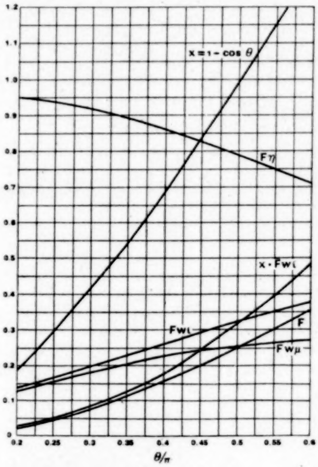

Fig. 4.

The input from the H.T. supply must be $Ea.Ia_m$ where Ia_m is the mean or average anode current over an audio cycle. Thus it is only necessary to determine Ia_m in order to assess the input from the H.T. source.

At any point, y, $Ia_y = Ia_c.F\eta_c/F\eta_y\ (1 + M \sin\phi)$, as derived in section 3.

It can be shown that $1/F\eta$ approximates very closely to $1 + \theta/\pi^2$ which may be substituted, giving

$$Ia_y = Ia_c.F\eta_c(1 + M\sin\phi)(1 + \theta/\pi_y{}^2)$$

i.e. $$Ia_y = Ia_c.F\eta_c(1 + M\sin\phi)\\ [1 + (\theta/\pi_c + M\sin\phi(\theta/\pi_t - \theta/\pi_c))^2]$$

Then $$Ia_m = Ia_c.F\eta_c.1/\pi\int_{-\pi/2}^{+\pi/2}(1 + M\sin\phi)\\ [1 + \theta/\pi_c{}^2 + 2M\sin\phi\,\theta/\pi_c(\theta/\pi_t - \theta/\pi_c)\\ + M^2\sin^2\phi(\theta/\pi_t - \theta/\pi_c)^2]d\phi$$

Again ignoring odd powers of $\sin\phi$ in the product, we have,

$$Ia_m = Ia_c.F\eta_c.1/\pi\int_{-\pi/2}^{+\pi/2}[1 + \theta/\pi_c{}^2\\ + M^2\sin^2\phi\,((\theta/\pi_t - \theta/\pi_c)^2\\ + 2\theta/\pi_c\,(\theta/\pi_t - \theta/\pi_c))]d\phi\\ = Ia_c.F\eta_c[1 + \theta/\pi_c{}^2 + M^2/2\\ (\theta/\pi_t{}^2 - \theta/\pi_c{}^2)]$$

∴ Actual input from the anode H.T. source =

$$Ea_c.Ia_c.F\eta_c[1 + \theta/\pi_c{}^2 + M^2/2(\theta/\pi_t{}^2 - \theta/\pi_c{}^2)]$$

If $M = 1$, $\theta/\pi_t = 0.5$, and $\theta/\pi_c = 0.35$.

Input = carrier input × 1.052, i.e. approximately five per cent. increase.

It should be noted that on the basis of constant efficiency there should be no increase in Ia on modulation, the necessary 50 per cent. increase in input coming solely from the modulator.

We now want to determine how the input from this source is affected by the change in efficiency over the audio cycle.

At any point y

Input from modulator = Total Input − Input from anode H.T. supply =

$$Ea_c(1 + M\sin\phi)Ia_c(1 + M\sin\phi)F\eta_c/F\eta_y\\ - Ea_c.Ia_c(1 + M\sin\phi)F\eta_c/F\eta_y\\ = Ea_c.Ia_c.F\eta_c/F\eta_y[(1 + M\sin\phi)^2\\ - (1 + M\sin\phi)]\\ = Ea_c.Ia_c.F\eta_c/F\eta_y(M\sin\phi + M^2\sin^2\phi)$$

∴ Average input from modulator source

$$= Ea_c.Ia_c.F\eta_c.1/\pi\int_{-\pi/2}^{+\pi/2}(M\sin\phi + M^2\sin^2\phi)\\ 1/F\eta_y\,d\phi\\ = Ea_c.Ia_c.F\eta_c.1/\pi\int_{-\pi/2}^{+\pi/2}(M\sin\phi + M^2\sin^2\phi)\\ [1.0 + (\theta/\pi_c + M\sin\phi(\theta/\pi_t - \theta/\pi_c))^2]d\phi$$

Ignoring odd powers of $\sin\phi$ we have

$$Ea_c.Ia_c.F\eta_c.1/\pi\int_{-\pi/2}^{+\pi/2}[M^2\sin^2\phi(2\theta/\pi_c(\theta/\pi_t\\ - \theta/\pi_c) + 1 + \theta/\pi_c{}^2) + M^4\sin^4\phi\\ (\theta/\pi_t - \theta/\pi_c)^2]\,d\phi\\ = Ea_c.Ia_c.F\eta_c[M^2/2(1 + 2\theta/\pi_t\theta/\pi_c - \theta/\pi_c{}^2)\\ + \tfrac{3}{8}M^4(\theta/\pi_t - \theta/\pi_c)^2]$$

If $M = 1$ this reduces to

$$Ea_c.Ia_c.F\eta_c/8[4 + (3\theta/\pi_t - \theta/\pi_c)(\theta/\pi_t + \theta/\pi_c)]$$

If $M = 1$, $\theta/\pi_t = 0.5$, and $\theta/\pi_c = 0.35$, this gives input from modulator source = 0.55 $Ea_c.Ia_c$, i.e. about ten per cent. increase on the value assuming constant efficiency.

Thus it is seen that the increased input is shared almost equally between the two power sources.

From the experimental tests made on the A.C.T.6 valve, the approximate inputs from the H.T. and modulator sources were calculated, and were found to agree closely on 100 per cent. modulation with the predicted values.

7. Effect of Non-Linearity

So far all the deductions have been based on the assumption of linearity of output, i.e.

$$\hat{e}a_y = \hat{e}a_c(1 + M \sin \phi)$$

In a self-biased amplifier this can often be very closely attained, but in many cases this is not the case, the amplifier being either over- or under-biased in the crest condition, so that θ/π departs from correct value for linearity giving reduced or increased outputs respectively. The former is more frequently the case in practice. The effect is derived for any given point on the modulation cycle as follows :—

As the load impedance is constant, $\hat{e}a/\hat{i}p$ is constant, whence also $\hat{e}a/\hat{i}a \,.\, Fw\mu$ is constant, so that at any point on the audio cycle of modulation,

$$\frac{\hat{e}a'}{\hat{i}a'.Fw\mu'} = \frac{\hat{e}a}{\hat{i}a.Fw\mu}$$

where $\hat{e}a'$, $\hat{i}a'$ and $Fw\mu'$ signify the altered values due to the departure from linearity.

$$\therefore \hat{i}a'/\hat{i}a = \frac{\hat{e}a' \,.\, Fw\mu}{\hat{e}a \,.\, Fw\mu'}$$

$$= \frac{h' \,.\, Fw\mu}{h \,.\, Fw\mu'} \quad \text{as } \hat{e}a = h.Ea$$

Now $\quad \hat{i}a = x \,.\, gm(\hat{e}g - \hat{e}a/\mu)$

$$\therefore \hat{i}a'/\hat{i}a = \frac{x'(\hat{e}g - \hat{e}a'/\mu)}{x(\hat{e}g - \hat{e}a/\mu)}$$

$$\therefore \hat{e}a'/\hat{e}a = \frac{x' \,.\, Fw\mu'(\hat{e}g - \hat{e}a'/\mu)}{x \,.\, Fw\mu(\hat{e}g - \hat{e}a/\mu)}$$

$$= \frac{F'(\hat{e}g - \hat{e}a'/\mu)}{F(\hat{e}g - \hat{e}a/\mu)}$$

This reduces to

$$\hat{e}a'/\hat{e}a = \frac{F'.\hat{e}g}{F.\hat{e}g + \hat{e}a/\mu(F' - F)}$$

Then

$$w\mu'/w\mu = (\hat{e}a'/\hat{e}a)^2$$

and $\quad \eta'/\eta = \dfrac{F' \,.\, F\eta'}{F \,.\, F\eta} \cdot \dfrac{(\hat{e}g - \hat{e}a'/\mu)}{(\hat{e}g - \hat{e}a/\mu)}$

If the change in θ/π is very small, then $\hat{e}a'/\hat{e}a \doteqdot F'/F$ and $\hat{i}a'/\hat{i}a \doteqdot x'/x$.

The effect on anode dissipation is as follows :

$$D'/D = \frac{Ea(1 + M \sin \phi)\hat{i}a'.Fwi'(1 - h'.F\eta')}{Ea(1 + M \sin \phi)\hat{i}a.Fwi(1 - h.F\eta)}$$

$$= \frac{x' \,.\, Fwi'(1 - h'.F\eta')}{x \,.\, Fwi(1 - h.F\eta)} \cdot \frac{(\hat{e}g - \hat{e}a'/\mu)}{(\hat{e}g - \hat{e}a/\mu)}$$

This formula shows that the ratio D'/D is not dependent solely on θ/π, so no general case can be worked out. If, however, the change in θ is small, and if $\hat{e}g$ is much larger than $\hat{e}a/\mu$, the formula can be regarded approximately as

$$D'/D \doteqdot \frac{x' \,.\, Fwi'(1 - h'.F\eta')}{x \,.\, Fwi(1 - h.F\eta)}$$

$$\doteqdot \frac{x' \,.\, Fwi'(1 - h.F\eta'.F'/F)}{x \,.\, Fwi(1 - h.F\eta)}$$

which is solely a function of θ. The effect of a given change in θ/π due to departure from linearity is thus calculable, the various factors being obtained from Fig. 4.

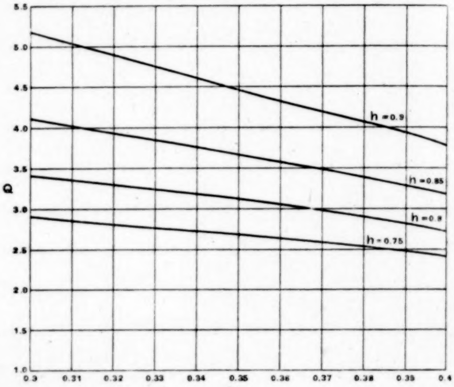

Fig. 5.—*Curves of* $Q = \dfrac{F\eta}{1 - h.F\eta}$ *against* θ/π_c, *with h as parameter.*

It was found by assuming values for θ/π_t and θ/π_t' that in the crest condition $D' \doteqdot D$, which suggests that non-linearity has little effect on the dissipation.

From the values of $\hat{e}g$, etc., measured in the previous tests, the effect of change of θ/π_t from 0.5 to 0.475 in the crest condition, was calculated for the case of the A.C.T.6 valve. Again D' was found to be approximately equal to D in the crest, and as the losses are greatest at this point, it is unlikely that the difference will be appreciable on the average over an audio cycle of modulation.

A practical test of the effect of non-linearity was made by injecting into the grid circuit, in series with a fixed bias of 100v., a voltage (20v. peak) of modulation frequency, this voltage being obtained from the modulator itself in order to ensure correct phase relationship. Three sets of readings were taken, as follows, the modulation being 100 per cent. in each case :—

(1) Injected voltage reducing the bias as the anode voltage increases, thus increasing θ/π above the correct value for linearity as the crest is approached.

(2) No injected voltage.

(3) Injected voltage increasing the bias as the anode voltage increases, thus reducing θ/π below the correct value for linearity as the crest is approached.

The following results were obtained.

Test No.	Anode current	Output (watts)	Anode dissipation (watts)	$\dfrac{\text{Anode dissipation}}{\text{Carrier anode dissipation}}$
1	103	104	51	1.96
2	100	95	50	1.925
3	96.5	86	48.5	1.87

These tests verify the theory that non-linearity has only a slight effect on the anode dissipation, and certainly does not account for the difference between the actual dissipation and that calculated on the basis of constant efficiency.

The reason, as can be deduced by examining the formula above, is that, as θ/π increases above the correct value for linearity, the input and efficiency both increase, and vice versa, which tends to keep the dissipation constant.

Conclusions

It has been shown that the actual anode dissipation in a non-compensated anode-modulated amplifier appreciably exceeds that in a compensated amplifier where the efficiency is constant over the modulation cycle. The usual assumption that the carrier dissipation may be 2/3 of the permissible maximum for the valve is therefore not justified if the average depth of modulation is greater than about 70 per cent. As, however, this depth is seldom exceeded except for short intervals of time, it is improbable that the valve will be overloaded. In fact it may be that when intermittent signals are being transmitted or when the average modulation depth is low, e.g. on speech or music, a larger carrier anode dissipation is permissible, provided, of course, that other limiting criteria are not thereby exceeded, thus giving greater carrier output. In any case it is clear that there is no universally correct fraction for the permissible carrier anode dissipation, and each case should be decided on its own merits from a knowledge of the nature of the signals to be transmitted and of the characteristics of the valve. The ratio of average to carrier dissipation will be less the lower θ/π_c, but this is limited by considerations of drive and distortion.

It has also been shown that departure from linearity has little effect on the average dissipation, but, of course, it is highly undesirable on its own account. A self-biased amplifier will in most cases give fairly good linearity, but if not, some form of compensation is desirable. Such compensation may be effected by one or other of the following methods.

(1) Keep $\hat{e}g$ constant and inject a bias voltage in phase with the modulation so as to give the correct value of θ/π as the crest is approached.

(2) Apply modulation to the grid or anode of the driver valve so that $\hat{e}g$ varies over the modulation cycle. This has the merit of reducing grid circuit losses in the trough of the modulation cycle, and also of giving higher efficiency in the crest, i.e. reduced average anode dissipation.

This latter scheme applied drastically and in conjunction with correct bias compensation of the amplifier may also be used, not only to give correct linearity, but also to reduce the average anode dissipation to the theoretical value of 1.5 times that in the carrier condition, $\hat{e}g$ and Eg being varied so as to give constant efficiency over the modulation cycle. This usually requires very high values of these factors in the crest, and it should be ascertained whether they are permissible for the type of valve before applying complete compensation. Otherwise partial compensation only should be applied.

(3) Partial compensation can be obtained by using a driver stage of poor regulation, due to the alteration in the loading over the modulation cycle. This will always be obtained to a certain extent from any driver.

Feedback in the amplifier circuit may also tend to give some compensation, as the amount depends on Ea. Exploitation of this is not, however, recommended.

Coupling Circuits as Band Pass Filters—Part III*

By E. K. Sandeman

(Continued from page 415 of October Issue)

The Single Series Tuned Mutual Coupling

THE circuit is shown at Fig. 1(a). At (b) is shown its equivalent circuit, derived by replacing the transformer constituted by the coupled inductances L_a and L_b by one of its equivalent circuits.

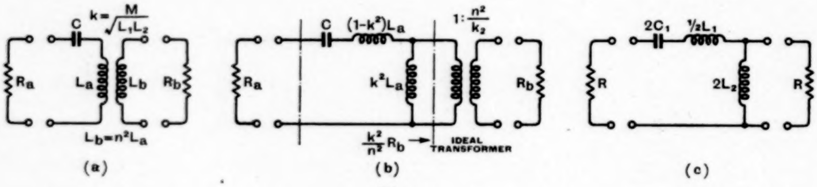

Fig. 1.

At (*c*) is shown a half section of Shea type III_2 filter; see "Transmission Networks and Wave Filters" by T. E. Shea, p. 316. The values of the elements of this filter are given by

$$L_1 = \frac{f_1 R}{\pi f_2 (f_2 - f_1)} \quad \ldots \quad \ldots \quad (1)$$

$$C_1 = \frac{f_2 - f_1}{4\pi f_1 f_2 R} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

$$L_2 = \frac{(f_1 + f_2) R}{4\pi f_1 f_2} \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

From the above it is evident that if $R_a = \frac{k^2}{n^2} R_b$, the network in Fig. 1(b), between the chain dotted lines, behaves like a half-section of Shea Type III_2 filter, when

$$C\ (\equiv 2C_1) = \frac{f_2 - f_1}{2\pi f_1 f_2 R_a} \quad \ldots \quad \ldots \quad (4)$$

$$(1 - k^2) L_a (\equiv \tfrac{1}{2} L_1) = \frac{f_1 R_a}{2\pi f_2 (f_2 - f_1)} \quad (5)$$

$$k^2 L_a (\equiv 2L_2) = \frac{(f_1 + f_2) R_a}{2\pi f_1 f_2}$$

$$= \frac{(f_1 + f_2)}{2\pi f_1 f_2} \cdot \frac{k^2}{n^2} R_b \quad \ldots \quad \ldots \quad (6)$$

From (6)

$$\frac{k^2}{n^2} L_b = k_2 L_a = \frac{f_1 + f_2}{2\pi f_1 f_2} \cdot \frac{k^2}{n_2} R_b$$

$$\therefore L_b = \frac{(f_1 + f_2) R_b}{2\pi f_1 f_2} \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

Adding (5) and (6)

$$L_a = \frac{f_1 R_a}{2\pi f_2 (f_2 - f_1)} + \frac{(f_1 + f_2) R_a}{2\pi f_1 f_2}$$

$$= \frac{[f_1^2 + f_2^2 - f_1^2] R_a}{2\pi f_1 f_2 (f_2 - f_1)} = \frac{f_2 R_a}{2\pi f_1 (f_2 - f_1)} \quad (8)$$

Dividing (6) by (8)

$$k^2 = \frac{(f_1 + f_2) R_a}{2\pi f_1 f_2} \cdot \frac{2\pi f_1 (f_2 - f_1)}{f_2 R_a} = \frac{f_2^2 - f_1^2}{f_2^2}$$

$$\therefore k = \sqrt{1 - \frac{f_1^2}{f_2^2}} \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

Summary

$$L_a = \frac{f_2 R_a}{2\pi f_1 (f_2 - f_1)}, \quad L_b = \frac{(f_1 + f_2) R_b}{2\pi f_1 f_2},$$

$$C = \frac{f_2 - f_1}{2\pi f_1 f_2 R_a}, \qquad k = \sqrt{1 - \frac{f_1^2}{f_2^2}}$$

The Double Series Tuned Mutual Coupling

The circuit is shown in Fig. 2(a). At (b) is shown its equivalent circuit for the case where $L_a = L_b = L$, $C_a = C_b = C$, $R_a = R_b = R$. This is derived by replacing the transformer constituted by the coupled inductances $L_a = L_b = L$ with its equivalent T. At (*c*) is shown a mid series terminated section of Shea Type III_2 filter. The values of the elements of this filter are given in equations (1), (2) and (3) above.

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* MS. accepted by the Editor, July, 1941.

From the above it is evident that the network of Fig. 2(b) behaves like a mid series terminated section of Shea Type III_2 filter when

$$C = 2C_1 = \frac{f_2 - f_1}{2\pi f_1 f_2 R} \tag{10}$$

$$(1 - k)L = \tfrac{1}{2}L_1 = \frac{f_1 R}{2\pi f_2 (f_2 - f_1)} \tag{11}$$

$$kL = L_2 = \frac{(f_1 + f_2)R}{4\pi f_1 f_2} \tag{12}$$

Adding (11) and (12)

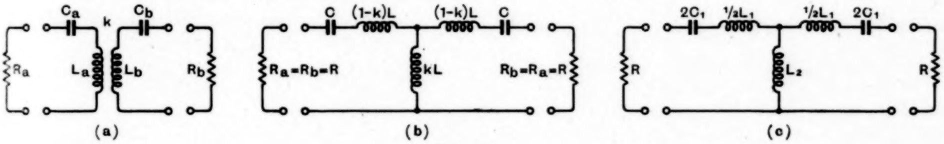
$$L = \frac{2f_1^2 + f_2^2 - f_1^2}{4\pi f_1 f_2 (f_2 - f_1)} R = \frac{(f_1^2 + f_2^2)R}{4\pi f_1 f_2 (f_2 - f_1)} \tag{13}$$

Dividing (12) by (13)

$$k = \frac{(f_1 + f_2)R}{4\pi f_1 f_2} \cdot \frac{4\pi f_1 f_2 (f_2 - f_1)}{(f_1^2 + f_2^2)R}$$

$$= \frac{f_2^2 - f_1^2}{f_1^2 + f_2^2} \tag{14}$$

By the same arguments that applied to the double parallel tuned mutual coupling, each side of this circuit can be designed independently of the other, substituting for R in the equations (10) and (13) the value of the impedance facing that side.



(a) (b) (c)

Fig. 2.

Summary

$$C_a = \frac{f_2 - f_1}{2\pi f_1 f_2 R_a} \qquad C_b = \frac{f_2 - f_1}{2\pi f_1 f_2 R_b}$$

$$L_a = \frac{(f_1^2 + f_2^2)R_a}{4\pi f_1 f_2 (f_2 - f_1)} \qquad Lb = \frac{(f_1^2 + f_2^2)R_b}{4\pi f_1 f_2 (f_2 - f_1)}$$

$$k = \frac{f_2^2 - f_1^2}{f_1^2 + f_2^2}$$

Inductance Capacitance π Section

The circuit of this is shown in Fig. 3; α, β and γ are the respective impedance of L, C_1, and C_2.

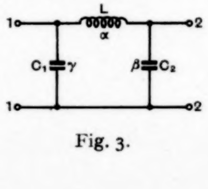


Fig. 3.

Put $\alpha = Lj\omega = a\omega$

$$\text{so that } a = jL \tag{15}$$

$$\beta = \frac{1}{C_1 j\omega} = \frac{-b}{\omega}$$

$$\text{so that } b = \frac{-1}{jC_2} = \frac{j}{C_2} \tag{16}$$

$$\gamma = \frac{1}{C_2 j\omega} = \frac{-c}{\omega}$$

$$\text{so that } c = \frac{-1}{jC_1} = \frac{j}{C_1} \tag{17}$$

Conventions

Z_1 = image impedance at 1, 1.
Z_2 = image impedance at 2, 2.
R_1 = geometric mid band image impedance at 1, 1.
R_2 = geometric mid band image impedance at 2, 2.
SC_1 = impedance at 1, 1 with 2, 2 short circuited.
SC_2 = impedance at 2, 2 with 1, 1 short circuited.
OC_1 = impedance at 1, 1 with 2, 2 open circuited.
OC_2 = impedance at 2, 2 with 1, 1 open circuited.
f_1, f_2 and f_3 = cut-off frequencies.
ω_1, ω_2 and ω_3 = respectively $2\pi f_1$, $2\pi f_2$ and $2\pi f_3$.
P = propagation constant of network.
$\frac{f_2}{f_1} = \phi$

Then

$$SC_1 = Z_1 \tanh P = \frac{\gamma\alpha}{\gamma + \alpha} \tag{18}$$

$$SC_2 = Z_2 \tanh P = \frac{\alpha\beta}{\alpha + \beta} \tag{19}$$

$$OC_1 = Z_1 \coth P = \frac{\gamma(\alpha + \beta)}{\alpha + \beta + \gamma} \tag{20}$$

$$OC_2 = Z_2 \coth P = \frac{\beta(\gamma + \alpha)}{\alpha + \beta + \gamma} \tag{21}$$

Hence, multiplying together (18) and (20)

$$Z_1{}^2 = \frac{\gamma^2\alpha(\alpha+\beta)}{(\alpha+\beta+\gamma)(\gamma+\alpha)} \quad \ldots \quad (22)$$

Similarly from (19) and (21)

$$Z_2{}^2 = \frac{\alpha\beta^2(\gamma+\alpha)}{(\alpha+\beta+\gamma)(\alpha+\beta)} \quad \ldots \quad \ldots \quad (23)$$

Incidentally, dividing (18) by (20)

$$\tanh^2 P = \frac{\alpha(\alpha+\beta+\gamma)}{(\alpha+\beta)(\gamma+\alpha)} \quad \ldots \quad \ldots \quad (24)$$

Dividing (18) by (19)

$$\frac{Z_1}{Z_2} = \frac{\gamma}{\beta}\cdot\frac{\alpha+\beta}{\gamma+\alpha} \quad \ldots \quad \ldots \quad \ldots \quad (25)$$

In equations (22), (23) and (25) put $\alpha = a\omega$, $\beta = \frac{-b}{\omega}$ and $\gamma = \frac{-c}{\omega}$

whence

$$Z_1{}^2 = \frac{\frac{c^2}{\omega^2}\cdot a\omega\left(a\omega - \frac{b}{\omega}\right)}{\left(a\omega - \frac{b}{\omega} - \frac{c}{\omega}\right)\left(-\frac{c}{\omega} + a\omega\right)}$$

$$= \frac{c^2a(a\omega^2-b)}{(a\omega^2-b-c)(a\omega^2-c)} \quad \ldots \quad (26)$$

$$Z_2{}^2 = \frac{b^2a(a\omega^2-c)}{(a\omega^2-b-c)(a\omega^2-b)} \quad \ldots \quad (27)$$

$$\frac{Z_1}{Z_2} = \frac{c}{b}\cdot\frac{a\omega - \frac{b}{\omega}}{a\,\omega - \frac{c}{\omega}} = \frac{c(a\omega^2-b)}{b(a\omega^2-c)} \quad \ldots \quad (28)$$

Cut-off frequencies

These occur when Z_1 and Z_2 are 0, 0; 0, ∞; ∞, 0 or ∞, ∞.

Three of these conditions can be satisfied by equating appropriate functions of ω to 0, in equations 26 and 27. The fourth condition cannot be realised with this type of structure.

There are therefore *three* cut-off frequencies to be considered, corresponding to ω_1, ω_2 and ω_3 where

$$\omega_1{}^2 = \frac{b}{a} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (29)$$

$$\omega_2{}^2 = \frac{b+c}{a} \quad \ldots \quad \ldots \quad \ldots \quad (30)$$

$$\omega_3{}^2 = \frac{c}{a} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (31)$$

Assuming $b > c$, i.e. $C_1 > C_2$ these cut-off frequencies are arranged as in Fig. 4.

This filter can therefore be designed: *either*

(1) To pass a band from 0 to f_3,

or (2) To pass a band from f_1 to f_2,

or (3) To pass a band from 0 to f_3 and from f_1 to f_2 *only* in the particular case where $f_3 = f_1$.

It can be shown that cases (1) and (3) lead to the same design in which $Z_1 = Z_2$. In both these cases there is therefore only a single pass band giving rise to the ordinary low pass filter.

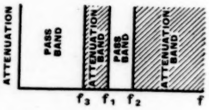


Fig. 4.

If the structure is designed to pass a band from f_1 to f_2 (i.e. case 2) the pass band from 0 to f_3 does not exist.

Case (2) is the one in which we are now interested since this is the only one which enables the section to be used as an impedance matching network by virtue of the fact that its image impedances are unequal.

Determination of the Values of the Elements to make the Structure constitute a Band-Pass Matching Filter

From equations (29) and (30)

$$\frac{\omega_2{}^2}{\omega_1{}^2} = \frac{b+c}{b} = 1 + \frac{c}{b} \quad \ldots \quad \ldots \quad (32)$$

Determination of L

Eliminate b and c between (26), (29) and (32).

From (29), $b = a\omega_1{}^2 \quad \ldots \quad \ldots \quad (33)$

From (32) $c = b\,(\frac{\omega_2{}^2}{\omega_1{}^2} - 1) = a(\omega_2{}^2 - \omega_1{}^2) \quad \ldots \quad \ldots \quad (34)$

Substituting (33) and (34) in (26).

$$Z_1{}^2 = \frac{a^3(\omega_2{}^2-\omega_1{}^2)^2(a\omega^2-a\omega_1{}^2)}{[a\omega^2-a\omega_1{}^2-a(\omega_2{}^2-\omega_1{}^2)]\,(a\omega^2-a\omega_2{}^2+a\omega_1{}^2)}$$

If $\omega^2 = \omega_1\omega_2$, since ω is the geometric mean of ω_1 and ω_2 (i.e. $f = \frac{\omega}{2\pi}$ is the geometric mid-band frequency)

$$Z_1{}^2 = R_1{}^2 = \frac{a^2(\omega_2{}^2-\omega_1{}^2)^2(\omega_1\omega_2-\omega_1{}^2)}{(\omega_1\omega_2-\omega_2{}^2)(\omega_1\omega_2-\omega_2{}^2+\omega_1{}^2)}$$

$$\therefore R_1{}^2 = -\frac{a^2\omega_1(\omega_2{}^2-\omega_1{}^2)^2}{\omega_2(\omega_1{}^2+\omega_1\omega_2-\omega_2{}^2)}$$

But $a = jL$, see equation (15).

$$\therefore a^2 = -L^2$$

and

$$L^2 = -a^2 = \frac{\omega_2(\omega_1^2 + \omega_1\omega_2 - \omega_2^2)}{\omega_1(\omega_2^2 - \omega_1^2)^2} R_1^2$$

$$\therefore L = \frac{R_1\sqrt{f^2/f_1(f_1^2 + f_1f_2 - f_2^2)}}{2\pi(f_2^2 - f_1^2)} \quad \cdots \quad \cdots \quad (35)$$

Putting $\frac{f_2}{f_1} = \phi$

$$L = \frac{R_1\sqrt{\phi(1 + \phi - \phi^2)}}{2\pi f_1(\phi^2 - 1)} \quad \cdots \quad (36)$$

Determination of C_1

Eliminate a and b between (26), (29), and (32).

From (32) $$b = \frac{c}{\frac{\omega_2^2}{\omega_1^2} - 1} \quad \cdots \quad \cdots \quad (37)$$

From (29) $$a = \frac{b}{\omega_1^2} = \frac{c}{\omega_2^2 - \omega_1^2} \cdots \quad (38)$$

Substituting (37) and (38) in (26)

$$Z_1^2 = \frac{\frac{c^3}{\omega_2^2 - \omega_1^2}\left[\frac{c\omega^2}{\omega_2^2 - \omega_1^2} - \frac{c}{\frac{\omega_2^2}{\omega_1^2} - 1}\right]}{\left[\frac{c\omega^2}{\omega_2^2 - \omega_1^2} - \frac{c}{\frac{\omega_2^2}{\omega_1^2} - 1} - c\right]\left[\frac{c\omega^2}{\omega_2^2 - \omega_1^2} - c\right]}$$

$$= \frac{c^3(c\omega^2 - c\omega_1^2)}{(c\omega^2 - c\omega_2^2)(c\omega^2 - c\omega_2^2 + c\omega_1^2)}$$

when $\omega^2 = \omega_1\omega_2$

$$Z_1^2 = R_1^2 = \frac{c^2(\omega_1\omega_2 - \omega_1^2)}{(\omega_1\omega_2 - \omega_2^2)(\omega_1\omega_2 - \omega_2^2 + \omega_1^2)}$$

$$= \frac{-c^2\omega_1}{\omega_2(\omega_1\omega_2 - \omega_2^2 + \omega_1^2)}$$

But $c = \frac{j}{C_1}$ see equation (17).

$$\therefore C_1^2 = -\frac{1}{c^2} = \frac{\omega_1 R_1^2}{\omega_2(\omega_1\omega_2 - \omega_2^2 + \omega_1^2)}$$

$$\therefore C_1 = \frac{1}{2\pi f_1 R_1\sqrt{f_2/f_1(1 + f_2/f_1 - f_2^2/f_1^2)}}$$

$$= \frac{1}{2\pi f_1 R_1\sqrt{\phi(1 + \phi - \phi^2)}} \quad \cdots \quad \cdots \quad (39)$$

Determination of C_2

Eliminate a and c between (27), (29) and (32)

From (29) $$a = \frac{b}{\omega_1^2} \quad \cdots \quad \cdots \quad (40)$$

From (32) $$c = b\frac{(\omega_2^2}{\omega_1^2} - 1) \quad \cdots \quad (41)$$

Substituting (40) and (41) in (27).

$$\therefore Z^2{}_2 = \frac{\frac{b^3}{\omega_1^2}\left[\frac{b\omega^2}{\omega_1^2} - b\left(\frac{\omega_2^2}{\omega_1^2} - 1\right)\right]}{\left[\frac{b\omega^2}{\omega_1^2} - b - b\left(\frac{\omega_2^2}{\omega_1^2} - 1\right)\right]\left[\frac{b\omega^2}{\omega_1^2} - b\right]}$$

$$= \frac{b^2(\omega^2 - \omega_2^2 + \omega_1^2)}{(\omega^2 - \omega_2^2)(\omega^2 - \omega_1^2)}$$

When $\omega^2 = \omega_1\omega_2$

$$Z_2^2 = R_2^2 = \frac{b^2(\omega_1\omega_2 - \omega_2^2 + \omega_1^2)}{(\omega_1\omega_2 - \omega_2^2)(\omega_1\omega_2 - \omega_1^2)}$$

$$= -\frac{b^2(\omega_1\omega_2 + \omega_1^2 - \omega_2^2)}{\omega_1\omega_2(\omega_2 - \omega_1)^2}$$

But $b = \frac{j}{c_2}$, see equation (16),

$$\therefore \frac{1}{b^2} = -C_2 = -\frac{\omega_1\omega_2 + \omega_1^2 - \omega_2^2}{\omega_1\omega_2(\omega_2 - \omega_1)^2 R_2^2}$$

$$\therefore C_2 = \frac{1}{2\pi(f_2 - f_1)R_2} \cdot \sqrt{\frac{f_1f_2 + f_1^2 - f_2^2}{f_1f_2}}$$

$$= \frac{1}{2\pi f_1(\phi - 1)R_2} \cdot \sqrt{\frac{1 + \phi - \phi^2}{\phi}} \quad (42)$$

Relation between $\frac{R_2}{R_1}$ and $\frac{f_2}{f_1} = \phi$.

From equation (28),

$$\frac{Z_2}{Z_1} = \frac{b(a\omega^2 - c)}{c(a\omega^2 - b)} \quad \cdots \quad \cdots \quad \cdots \quad (43)$$

Eliminate b and c between (33), (34) and (43).

$$\therefore \frac{Z_2}{Z_1} = \frac{a\omega_1^2(a\omega^2 - a\omega_2^2 + a\omega_1^2)}{a(\omega_2^2 - \omega_1^2)(a\omega^2 - a\omega_1^2)}$$

Putting $\omega^2 = \omega_1\omega_2$

$$\frac{Z_2}{Z_1} = \frac{R_2}{R_1} = \frac{f_1^2(f_1f_2 - f_2^2 + f_1^2)}{(f_2^2 - f_1^2)(f_1f_2 - f_1^2)}$$

$$= \frac{1 + \phi - \phi^2}{(\phi^2 - 1)(\phi - 1)} \quad \cdots \quad \cdots \quad (44)$$

Summary

If $Z_2 > Z_1$

$$L = \frac{R1\sqrt{\phi(1 + \phi - \phi^2)}}{2\pi f_1(\phi^2 - 1)} \quad \cdots \quad (45)$$

$$C_1 = \frac{1}{2\pi f_1 R_1 \sqrt{\phi(1+\phi-\phi^2)}} \quad \cdots \quad (46)$$

$$C_2 = \frac{1}{2\pi f_1 R_2(\phi-1)}\sqrt{\frac{1+\phi-\phi^2}{\phi}} \quad (47)$$

$$\frac{R_2}{R_1} = \frac{1+\phi-\phi^2}{(\phi^2-1)(\phi-1)} \quad \cdots \quad \cdots \quad (48)$$

calculated for the circuit shown in Fig. 5, in which R_1, R_2, L, C_1 and C_2 have the above values.

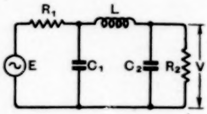


Fig. 5.

It can be shown by elementary circuit analysis, that in the structure of Fig. 5

$$\frac{V}{E} = \frac{\dfrac{R_2}{C_1\omega}}{R_1\left(L\omega - \dfrac{1}{C_1\omega}\right) + \dfrac{R_2C_2}{C_1}\left(L\omega - \dfrac{1}{C_2\omega}\right) - j\left[R_1R_2\left(1 + \dfrac{C_2}{C_1} - LC_2\omega^2\right) + \dfrac{L}{C_1}\right]}$$

It is to be noted that as ϕ (i.e. $\frac{f_2}{f_1}$) is increased from unity the value of the ratio $\frac{R_2}{R_1}$ falls, reaching unity when $\frac{f_2}{f_1} = \sqrt{2}$. For this reason the above equations cannot be used for values of $f_2\ f_1$ outside the limits 1 and $\sqrt{2}$.

This structure is interesting in that it has the form of a low pass filter, but can be given band pass properties by the assignment of proper values to its elements. As the author was inclined to be sceptical of the validity of the above reasoning an example was taken.

Example

A filter was designed to pass a band from 1.0 to 1.1 Mc/s and to work from a low impedance of 1,000 Ω;

i.e., $f_1 = 1.0 \,.\, 10^6$, $f_2 = 1.1 \,.\, 10^6$, $R_1 = 1{,}000\Omega$

Hence $\phi = 1.1$, $\phi^2 = 1.21$, $1 + \phi - \phi^2 = 0.89$

$$\phi(1+\phi-\phi^2) = 0.98$$

$$\sqrt{\phi(1+\phi-\phi^2)} = 0.99$$

$$L = \frac{10^3 \times 0.99}{2\pi \,.\, 10^6 \times 0.21} = 75\ \mu H$$

$$C_1 = \frac{10^{12}}{2\pi \,.\, 10^6 \,.\, 10^3 \times 0.99} = 161\mu\mu\text{F}$$

$$C_2 = \frac{0.21 \times 10^{12}}{2\pi \,.\, 10^6 \,.\, 10^3 \times 0.99} = 33.8\ \mu\mu\text{F}$$

$$\frac{Z_2}{Z_1} = \frac{0.89}{0.21 \times 0.1} = 42.3$$

$$Z_2 = 42{,}300$$

The ratios between E and V were then calculated for the circuit shown in Fig. 5, in which R_1, R_2, L, C_1 and C_2 have the above values.

When at any frequency the structure behaves as an ideal transformer between the resistances R_1 and R_2 inspection shows that

$$V = \tfrac{1}{2}E\sqrt{\frac{R_2}{R_1}} \quad \text{or} \quad \frac{V}{E} = \tfrac{1}{2}\sqrt{\frac{R_2}{R_1}}$$

At any other frequency therefore the loss in decibels is given by

$$20 \log_{10}\frac{V}{E} - 20 \log_{10}\tfrac{1}{2}\sqrt{\frac{R_2}{R_1}}$$

$$= 20 \log_{10}\frac{2v}{E}\sqrt{\frac{R_1}{R_2}}$$

This loss is plotted in Fig. 6.

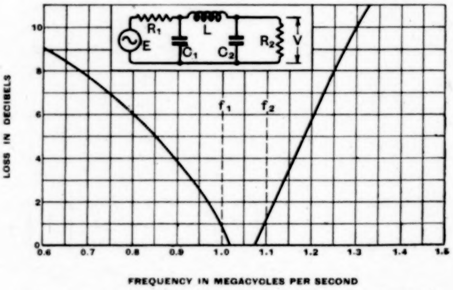


Fig. 6.—*Loss of structure (inset) designed with cut-off frequencies $f_1 = 10^6$ Mc/s and $f_2 = 1.1 \,.\, 10^6$ Mc/s when terminated in resistances R_1 and R_2, respectively equal to the geometric mid-band image impedances.*

It will be seen that the loss at the cut-off frequencies is not zero but a finite quantity of about a decibel. This is because the structure is terminated in its mid-band image impedances, and the image impedances are not constant over the band, the maximum deviation from the mid-band image impedance occurring at the cut-off frequencies.

(*To be concluded*)

Wireless Patents

A Summary of Recently Accepted Specifications

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

534 882.—Loudspeaker and microphone transmitter, suitable for use in a two-way telephone conference system.

Standard Telephones and Cables (assignees of L. G. Bostwick). Convention date (U.S.A.) 20th December, 1938.

535 391.—Microphone amplifier of the differential type actuated through a mechanical coupling from a piezo-electric crystal, a moving coil or armature.

G. E. Fountain and A. E. C. Snell. Application date 7th October, 1939.

535 906.—Electrical volume compressing and expanding arrangement, with a common gain-control device.

Standard Telephones and Cables and C. B. Ross. Application date 24th October, 1939.

536 615—.Negative feed-back volume-control network for audio-frequency amplifiers.

Amalgamated Wireless (Australasia). Convention date (Australia) 15th November, 1938.

536 616.—Negative feed-back circuit for preventing distortion in a broadcast amplifier outfit as used for "splitting" a programme between several lines.

Amalgamated Wireless (Australasia). Convention date (Australia) 15th November, 1938.

AERIALS AND AERIAL SYSTEMS

536 526.—Short-wave transmitting aerial, comprising a number of half-wave dipoles arranged cylindrically about a common vertical axis for radiating a horizontally polarised wave.

Marconi's W.T. Co. (assignees of N. E. Lindenblad). Convention date (U.S.A.), 8th September, 1938.

536 823.—A short-wave aerial with a feeder including a number of quarter-wave elements operating as interference preventers.

Cie Generale de T.S.F. Convention date (France) 24th November, 1938.

537 215.—Aerial array or network for unidirectional transmission or reception within a narrow angle.

E. W. Hayes. Application date 8th September, 1939.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television.*)

535 969.—Means for preventing the shunt effect of the electrode-capacitances of thermionic amplifiers when handling short waves.

Hazeltine Corporation (assignees of R. L. Freeman). Convention date (U.S.A.) 22nd October, 1938.

535 993.—A discriminator circuit, of the phase-measuring type, associated with a rectifier network for automatic tuning control.

Marconi's W.T. Co. and N. M. Rust. Application date 17th August, 1939.

536 004.—Automatic method of contrast control to minimise the effect of interference in a receiver.

Marconi's W.T. Co.; N. M. Rust; and J. D. Brailsford. Application date 13th November, 1939.

536 035.—Means for preventing the falling-off in signal-to-noise ratio which usually accompanies the application of volume control whether automatic or manual.

Marconi's W.T. Co. and E. E. Zeppler. Application date 21st November, 1939.

536 041.—Wireless receiver with means for automatically eliminating the kind of interference known as side-band splash.

Philips Lamps. Convention date (Netherlands) 30th January 1939.

TELEVISION CIRCUITS AND APPARATUS

FOR TRANSMISSION AND RECEPTION

535 331.—Synchronising system, particularly for television, in which the desired impulses are used to produce a control which automatically excludes undesired signals.

Philco Radio and Television Corporation (assignees of F. J. Bingley). Convention date (U.S.A.) 12th August, 1938.

535 387.—Time-base circuit for a cathode-ray television tube in which negative reaction is applied to prevent phase distortion.

Standard Telephones and Cables and W. A. Montgomery. Application date 6th October, 1939.

535 395.—Synchronising system, for television or a tape facsimile recorder, in which the local oscillation is derived from a dynatron generator.

Marconi's W.T. Co. (assignees of J. N. Whittaker). Convention date (U.S.A.) 8th October, 1938.

535 578.—Means for producing and controlling the so-called "odd-line" type of interlaced scanning in television.

Marconi's W.T. Co. (assignees of S. W. Seeley). Convention date (U.S.A.) 6th October, 1938.

535 633.—Television system in which a certain deliberate distortion is superposed on the signals in order to achieve greater ultimate fidelity.

Hazeltine Corporation (assignees of H. M. Lewis). Convention date (U.S.A.) 17th January, 1939.

535 661.—Means for eliminating the shunt effect of the valve electrodes in a saw-tooth oscillation generator, particularly for television.

Hazeltine Corporation (assignees of H. A. Wheeler). Convention date (U.S.A.) 4th November, 1938.

535 778.—Saw-tooth oscillation-generator of the multi-vibrator type, using coupling networks having predetermined time constants.
E. L. C. White. Application date 3rd October, 1939.

535 905.—Scanning arrangement for television in which the scanning spot in its traverse is given a slight lateral vibration, so that it marks out a fine zigzag course.
Standard Telephones and Cables; D. S. B. Shannon; and P. K. Chatterjea. Application date 24th October, 1939.

536 089.—Thermionic amplifier circuit with a "gamma" correction controlled by negative feedback, for use in televising from a cinema film.
A. D. Blumlein. Application date 28th July, 1939.

536 289.—Method of scanning and projection for a television system embodying a supersonic light-modulating device and suitable for use in theatres.
Scophony and F. Okolicsanyi. Application date 3rd July, 1939.

536 290.—Optical focusing means, having powers in two different directions, for projecting large-scale television pictures.
Scophony and F. Okolicsanyi. Application date 3rd August, 1939.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

535 701.—Cathode-ray tube for generating a short-wave carrier, modulated by time-modulated pulses.
Standard Telephones and Cables; W. A. Beatty; and C. T. Scully. Application date 13th October, 1939.

535 866.—Secondary-emission screen for an image-amplifying cathode-ray tube.
Marconi's W.T. Co. (assignees of H. A. Iams). Convention date (U.S.A.) 30th November, 1938.

536 221.—Composition of an electronically-active metal alloy, particularly for the cathodes of thermionic valves.
Marconi's W.T. Co. Convention date (U.S.A.) 30th September, 1938.

536 417.—Electron multiplier, particularly for television, in which the path of the electron stream approaching a secondary-emission target, is displaced from the path of the augmented stream after impact.
H. G. Lubszynski and H. Miller. Application date 3rd November, 1939.

SUBSIDIARY APPARATUS AND MATERIALS

535 385.—Remote tuning-control system in which high-frequency signals are used to produce a movement in the desired direction of the apparatus or component under control.
Standard Telephones and Cables; W. A. Beatty; and C. T. Scully. Application date 6th October, 1939.

535 388.—Means for nullifying the effects of static interference or fading in multiplex carrier-wave telegraphy.
Creed & Co.; R. D. Salmon; and F. P. Mason. Application date 6th October, 1939.

535 477.—Arrangement of the core and energising coils of the electromagnetic deflecting system of a cathode-ray tube designed to produce a uniform control field over a large cross-sectional area.
Baird Television Co. and D. V. Ridgeway. Application date 9th October, 1939.

535 507.—Piezo-electric crystal-oscillator in which the plates have different Curie points in order to improve the temperature-frequency characteristic.
Electrical Research Products Inc. Convention date (U.S.A.) 5th April, 1939.

535 525.—Wave filter comprising a vibratory system in which a magnetostrictive or similar mechanical oscillator is coupled to a piezo-electric crystal.
Standard Telephones and Cables (assignees of W. P. Mason). Convention date (U.S.A.) 19th July, 1939.

535 767.—Oscillation generator operating on the "Klystron" principle, but utilising a method of reflexing.
A. H. Stevens (communicated by The Board of Trustees of The Leland Stanford Junior University). Application date 9th August, 1939.

535 834.—Wide-band amplifier with inter-valve couplings of the transmission-line type.
Marconi's W.T. Co. (assignees of C. W. Hansell). Convention date (U.S.A.) 26th November, 1938.

The Industry

To meet the demand for a lead-free solder for certain specifications, Multicore Solders, Ltd., Bush House, London, W.C.2 are now producing pure tin with three cores of "Ersin" flux in gauges from 10 to 22 S.W.G.

Publication No. 105 issued by the Tin Research Institute, Fraser Road, Greenford, Middlesex, gives details of spectrographic methods of determining impurities in lead-tin solders.

Gas expanded rubber and ebonite cellular materials and their mechanical and thermal properties are described in a well-illustrated brochure received from the Expanded Rubber Co., Ltd., 675, Mitcham Road, Croydon. The firm notifies its willingness to co-operate in the development of new applications of these materials.

Stratton & Co., Ltd., the makers of "Eddystone" components, whose new address in Alvechurch Road, West Heath, Birmingham 21, have issued a loose-leaf folder with technical leaflets describing the components now available.

A limited number of technical catalogues dealing with high-vacuum diffusion pumps working with oil and mercury has been printed for W. Edwards and Co. (London), Ltd., Southwell Road, Loughborough Junction, London, S.E.5. Copies will be sent to readers who may be interested.

Abstracts and References

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For the information of new readers it is pointed out that the length of an abstract is generally no indication of the importance of the work concerned. An important paper in English, in a journal likely to be readily accessible, may be dealt with by a square-bracketed addition to the title, while a paper of similar importance in German or Russian may be given a long abstract. In addition to these factors of difficulty of language and accessibility, the nature of the work has, of course, a great influence on the useful length of its abstract.

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PROPAGATION OF WAVES

2958. ELECTROMAGNETIC WAVES IN METAL TUBES OF RECTANGULAR CROSS-SECTION [Expressions for Attenuation (agreeing with Those obtained by More Elaborate Means) derived from Ordinary Telephone Transmission Formulae: revealing a Link between Wave-Guide & Line Transmission].—J. Kemp. (*Journ. I.E.E.*, Sept. 1941, Vol. 88, Part III, No. 3, pp. 213–218.) From the Standard Telephones & Cables laboratories.

2959. WAVE GUIDES [Survey, with Writer's Experimental Work—Resonant Chamber for Practically Uniform Field (Area 400 cm^2) on 80 cm Wave: Calculated & Measured Radiation Patterns of Horizontally Flared Horn for 17 & 19 cm Waves].—J. E. Houldin. (*G.E.C. Journal*, Feb. 1941, Vol. 11, No. 3, pp. 172–181.)

2960. RANGE OF ULTRA-SHORT WAVES: CONDITIONS FOR PROPAGATION OVER EXCEPTIONALLY LONG DISTANCES [by the Various Mechanisms: Wavelengths down to 3 m].—T. W. Bennington. (*Wireless World*, Sept. 1941, Vol. 47, No. 9, pp. 228–230.) *Cf.* Hess, 2335 of September.

2961. OPTICS OF ATMOSPHERIC HAZE [Theory & Experiment].—E. O. Hulburt. (*Journ. Opt. Soc. Am.*, July 1941, Vol. 31, No. 7, pp. 467–476.) *See* also Byram, "The Polarisation of Atmospheric Haze," *Science*, 22nd Aug. 1941, pp. 192–193.

2962. RESEARCHES ON THE ELECTRICAL CONSTANTS OF THE GROUND FOR ULTRA-SHORT [3–9 m] WAVES.—L. Sacco. (*La Ricerca Scient.*, Oct. 1940, Vol. 11, No. 10, pp. 718–724.)

It was desired to check experimentally the theoretical results on the propagation of metric waves over land, particularly the American work between 1933 and 1937, with a view to applying the theoretical relations, simplified as far as possible, to practical requirements. After a consideration of experimental methods already published it was decided, at the "G. Marconi" Experimental Centre, to employ two methods: the first being to measure the angle of lag occurring in ground reflection for quasi-normal incidence, for vertical and horizontal polarisations, while the second consisted in the measurement of the attenuation and phase constants of a line buried in the ground and excited by the metric waves. The first method involves the compilation and working out of a number of graphs, and since this is now being carried out by the Institute for the Applications of Calculus, only the results of the second method are reported here: a further paper, with Barzilai, will describe the experimental side of the work, whose theory is here outlined.

Very satisfactory results were obtained with the ground at the Centre: γ was found to be 0.850, 0.697, & 0.504×10^{-2} mhos/m for 3, 6, & 9 m waves respectively, thus showing a definite tendency to increase with frequency, in agreement with experimental results on longer waves (Smith-Rose, 1934 Abstracts, p. 609): while on the other hand ϵ decreased with increasing frequency, the values being 4.92, 5.53, & 5.85 for wavelengths of 3, 6, & 9 m respectively. The increase, with frequency, of the ratio ϵ/q is thus evident: putting $q = 60\lambda\gamma$, the ratio works out at 2.15, 2.21, & 3.21 for the 9, 6, & 3 m waves respectively, so that as the frequency was increased the ground tested behaved more and more as a dielectric (Smith-Rose, *loc. cit*: Grosskopf & Vogt, 1833 of July). "But we are still a long way from a truly clear prevalence of such dielectric behaviour, seeing that the above ratios are comparatively little greater than unity", and it is just this unfortunate near-equivalence of ϵ and q that produces difficulty in applying theoretical results to represent actual propagation.

2963. On Observations of the Doppler Effect in the Short-Wave Reception Field [Effects of Motion of an Aeroplane in Neighbourhood of Receiving Aerial]. — J. Grosskopf & K. Vogt. (*Hochf:tech. u. Elek:akus.*, June 1941, Vol. 57, No. 6, pp. 143–146.)

"Scattered over the literature are to be found references to the occurrence of periodic changes in the intensity of signals, particularly in the u.s.w. band, produced by moving objects in the neighbourhood of the receiving aerial. Thus Englund, Crawford, & Mumford [1933 Abstracts, p. 381, and 417 of 1939] reported that an aeroplane flying at a height of about 460 m along the line between transmitter and receiver caused periodic variations of field strength with a frequency of about 4 c/s. In the present paper a report is made of a series of systematic tests carried out in connection with investigations of the re-radiation effect of diffracting and scattering obstacles in the wave-path" [the writers' paper in *T.F.T.* (1833 of July) is referred to here, though the connection—except perhaps to a few paragraphs dealing with diffraction at hillocks and woods—is not clear]. In the theoretical vector diagram of Fig. 1, *A* is the receiving aerial; $\mathfrak{u}$ the unit vector of the incident wave; $\mathfrak{v}$ the velocity vector of the aeroplane, making an angle γ with the line of $\mathfrak{u}$; the vector $\mathfrak{p}$ is the normal distance of the aerial from the path of flight, and $\mathfrak{r}$ (the vector from *A* at an angle α to the vector $\mathfrak{p}$) is the ray path from aerial to aeroplane. From this diagram is derived eqn. 1 for the beat frequency between direct and reflected rays: $f = v/\lambda \,.\, (\sin\alpha + \cos\gamma)$. Assuming horizontal flight, with a given $\mathfrak{u}$ and λ the equation contains 4 unknowns, two velocity components and two cosines of direction. Simultaneous observation of the four beat frequencies in the field of four transmitters would give the velocity and direction of the aeroplane: location by this process would be "reichlich umständlich", which translated literally means "abundantly circumstantial", but more colloquially signifies "pretty complicated".

The following special cases are considered, for comparison with experimental results:—the aeroplane flies along the joining line between transmitter and receiver (Fig. 2: eqn. 2): $f = v/\lambda \,.\, (1 + \sin\alpha)$, and the beat frequency depends only on the angle of incidence α, being in the zenithal case ($\alpha = 0°$) half as large as for $\alpha = 90°$. For $v = 50$ m/s and $\lambda = 20$ m, $f_{\max}$ is 5 c/s and $f_{zen} = 2.5$ c/s (Fig. 3). Another special case is for flight over the aerial but across the line: $f = v/\lambda \,.\, \sin\alpha$, so that the beat frequency is zero in the zenithal case and symmetrical on both sides (eqn. 3 and Fig. 4). Finally, flight over the aerial, at 45° to the line, away from the transmitter: $f = v/\lambda \,.\, (\sin\alpha + 0.707)$, and zero beat note is obtained for $\alpha = -45°$ (eqn. 4 and Fig. 5).

The theory was tested at a distance of 35 km from the Zeesen telephone transmitter, working on 15.3 Mc/s: two receiving aerials were erected with a base of 60 m at right angles to the line to the transmitting station. The rectified l.f. outputs were continuously recorded with a double inkwriter. The aeroplane employed had a speed of about 50 m/s, and flew over the aerial at heights of 200, 500, and 1000 m. In the records shown the direction of flight is given as N–S, etc: the transmitter was practically due South of the receiving station. The zenith passage of the aeroplane is marked on the records by arrows labelled "*Z*". Data for the beat-frequency characteristic as a function of the angle of incidence α are taken from the top record of Fig. 7 (flying height 1000 m, towards transmitter) and plotted in Fig. 8, together with the calculated values (open circles) from eqn. 2: extremely good agreement is shown. The measured zenithal frequency was 2.7 c/s, corresponding to a speed of 53 m/s. Eqn. 1 indicates that the beat frequency would be independent of the flying height, depending only on the angle α: table 1 shows that for $\alpha = +40°$ the measured *f* was 1.0 c/s, 1.0 c/s, and 0.9 c/s for heights of 200 m, 200 m (misprint for 500 m?), and 1000 m respectively. The amplitude variations shown in the records are merely results of the inertia of the recording system. Comparison of the 200 m flight records, N–S in Fig. 7 and S–N in Fig. 9, shows that the reversal of direction causes a reversal, in time, of the beat-frequency behaviour. Records of transverse flights (lower two curves of Fig. 9, of the symmetrical character predicted by eqn. 3 and Fig. 4) show that the zero points for the two aerials have a displacement in time corresponding to their spacing (the 60 m base in Fig. 6). The east wind blowing at the time made the process in the E–W direction occur more rapidly than in the W–E direction, as is shown by the different lengths of the two records. Fig. 10 shows flights at 45° to the line between the transmitter and receiver, away from and towards the transmitter: for the latter flight (NE–SW) the beat frequencies as a function of α are plotted in Fig. 11, which agrees well with the curve of Fig. 5 calculated from eqn. 4: "the measured α for zero beat has a smaller value [than that calculated] on account of the east wind mentioned above". The amplitude ratio of the re-radiated and ground waves was about 1 : 2. This comparatively high value of re-radiation is to be attributed to the pronounced dependence on height of the field strength of the reception field. With an accurate knowledge of this dependence combined with an inertia-free amplitude recorder, quantitative conclusions are possible as to the value of the re-radiation coefficient. Circular flight tests brought to light a marked dependence of the re-radiation coefficient of the aeroplane on direction. A further report will deal with this dependence and with the frequency characteristic of the re-radiation coefficient.

2964. On Some Observations on Field-Strength Recordings in the Short-Wave Band [particularly the German P.O. Fading Records of 15–60 m Waves (especially 25 m) over Comparatively Short Distances —500–3000 km].—J. Grosskopf. (*T.F.T.*, May 1940, Vol. 29, No. 5, pp. 127–137.)

Mögel (1934 Abstracts, p. 553), among others, has covered the behaviour of these waves over transoceanic distances up to 12 000 km. Recently, attention has been concentrated on the shorter ranges, and Figs. 1–3 reproduce the 500, 1500, and 2000 km curve families given by Maeda, Yokoyama,

& Tukada (4286 of 1939), covering a whole year. The German results now given and discussed are limited to the period Feb./June 1939, so that no such complete curves can be given; but so far as they go they agree in general with the Japanese observations. For special results *see* 2047 of August, where in the first paragraph this paper is discussed.

2965. On Night Ionisation at Polar Latitudes.—N. D. Bulatov. (*Journ. of Tech. Phys.* [in Russian], No. 2, Vol. 10, 1940, pp. 142–144.)

Taking into account the relationship between the height of the sun and the ionisation of the upper layers of the atmosphere, it can be assumed that ionisation at polar latitudes during the polar night must be exceptionally low, since under these conditions the ionosphere is not at all subjected to the action of the sun's rays. It appears, however, from an inspection of the curves showing the variation of the critical frequency of the F layer at various places that the ionisation at Franz Joseph Land (80° N) during the polar night greatly exceeds the night ionisation at Leningrad (60° N) and Tomsk (56° N). In order to explain this phenomenon a study is made of the relative positions of sun and earth, and it is shown that the upper layers of the atmosphere at heights not exceeding about 500 km at the geographical pole and approximately 1370 km at latitudes of the order of 80° are continuously illuminated by the sun. It is possible that this accounts for the observed phenomenon, and it is suggested that in planning radio communications at latitudes of 80°–60° the illumination of the very high layers of the atmosphere should be taken into account.

2966. Studies of a Ring Discharge [in Mercury Vapour at 2×10^{-4} mm: Observed Limitation of Degree of Ionisation explained by Hypothesis involving Recombination of Ion & Electron with Conservation of Electrical Energy].—C. G. Smith. (*Phys. Review,* 15th June 1941, Vol. 59, No. 12, pp. 997–1004.)

"Recombination varying as N^2 and ionic production varying as N would lead to an expected limitation upon N. Also the postulate leads to an immediate visualisation of a means of interchange of energy among electrons."

2967. Reflection of Electromagnetic Waves at an Inhomogeneous Layer according to the Wentzel - Kramers - Brillouin Method.—W. Kofink & E. Menzer. (*Ann. der Physik,* 4th May 1941, Vol. 39, No. 5, pp. 388–402.)

"After a short discussion of the wave equations for $\mathfrak{E}$ and $\mathfrak{H}$ in an inhomogeneous medium (section 1) we establish in section 2 an exact formula for the reflecting power of an inhomogeneous layer, which we then, by the introduction of the W.K.B. method [*see* also Deb, 2623 of October], transform into an approximate formula which now contains only the index of refraction and its derivatives. It is valid so long as $(\lambda/4\pi \,.\, n'/n)^2 \ll 1$, with corresponding assumptions as to the higher derivatives of the refractive index. In section 3 we compare this approximation with a special example exactly solved by Schlick [in 1904], in which the refractive index has the form $n(z) = A/z$. In section 4 the reflecting power is found for layers at whose borders either the refractive index itself, or its first or higher derivative, possesses a point of discontinuity, and in section 5 the question is discussed when the reflecting power of an inhomogeneous layer possesses the same functional appearance as that of a homogeneous layer of average refractive index" [in this connection Schröder's paper (2077 of August) is mentioned].

2968. On the Temperature of the Upper Atmospheric Layers. — E. Regener. (*Naturwiss.,* 8th Aug. 1941, Vol. 29, No. 32/33, pp. 479–484.)

Recent observations and calculations have led to the assumption of temperatures of + 50° to 70° C for the upper part (at 40–45 km) of the ozone layer, of + 35° to 100° for the E layer, and of + 160° to 660° for the F layers. Doubts are still expressed, from the meteorological side, as to the reality of these temperatures (Wegener, *Meteorol. Zeitschr.,* 1940, Vol. 57, p. 290) but these doubts cannot be maintained in the face of the material available. In particular, a recent paper by Penndorf (2969, below) has collected the temperature values calculated by various workers for the ozone and ionospheric layers, and has discussed them fully (for another paper by Penndorf, *see* 1582 of June). The fact that optical results on the auroral region have hitherto yielded temperatures well below those calculated for the ionosphere at a similar height is also discussed in the paper, and the discrepancy explained as the result of different observational conditions. The present writer, therefore, assumes the reality of the increased temperatures in the upper layers, and omits further discussion of the actual values. He concentrates on elucidating, by considerations of a general nature, the problem of how such rises of temperature can occur.

After discussing the extremely high absorption coefficients (for a reduction to one-tenth of the incident intensity) of the components of the upper atmosphere, for short-wave ultra-violet radiations, he explains the formation of the ozone layer, the E layer, and the F layers as due respectively to absorption by oxygen of wavelengths 0.175–0.205 μ, by oxygen again of wavelengths around 0.145 μ, and by nitrogen of wavelengths under 0.1 μ. Difficulties in the way of a more precise working out of these rough ideas are caused by the fact that the absorbing wavelengths form, in reality, band spectra of very complicated structure in which the absorption changes very sharply from one wavelength to another, and whose composition in the extreme ultra-violet is still incompletely known. But the mere fact of the existence of these high absorption coefficients makes the warming of the upper layers comprehensible, since only a small part of the absorbed solar energy is taken up in chemical transformations and ionisation (p. 481, r-h column). The question how far it may be possible to calculate the resulting temperatures by radiation theory is considered on the next pages, and it is concluded that not enough data exist for such a calculation as regards the ionospheric layers, except to deduce that the results are quite consistent with the temperature values demanded by their electrical properties. More data are available for the ozone layer, and the temperature calculated for this by Penndorf and by Gowan (1928 Abstracts, p. 683) has already been cited. Here, however, the cooling effect of the not definitely known water-vapour content, and the question of heat transfer to the lower air layers (which does not come appreciably into the case of the ionospheric layers), complicate matters.

Finally, on p. 484, the optical method of estimating the layer temperatures from the structure of definite absorption or emission bands is discussed. Thus for ozone, with decreasing temperature the minima between the individual elements of the Huggins band (0.32 to 0.36 μ) become more pronounced, and laboratory calibrations can be used to obtain the actual temperature of the atmospheric ozone layer. Already some such measurements have been made: at present they have the defect that they give only the average temperature of the whole layer, whereas actually only the upper part has the heightened temperature. Auroral measurements by this method suffer from the long exposures made necessary by the weak intensity of the radiation. The final paragraph stresses the importance of further development of this optical method: at present the determination of temperature is only a by-product of the technique, which has already led to valuable information on the sodium and calcium layers, the light of the night sky, etc.

2969. PAPER ON THE TEMPERATURES OF THE UPPER ATMOSPHERIC LAYERS.—R. Penndorf. (*Meteorol. Zeitschr.*, 1941, Vol. 58, p. 1 onwards.) Referred to in Regener's article, 2968, above.

2970. LOUISE A. BOYD ARCTIC EXPEDITION [for Ionospheric, Geomagnetic, & Other Measurements].—(*Journ. Franklin Inst.*, July 1941, Vol. 232, No. 1, p. 59.)

2971. FADE-OUT WITHIN FIVE MINUTES OF HYDROGEN ERUPTION ON SUN [lasted Five Minutes, but was followed later in morning by One of Two Hours' Duration: Effect on Echoes].—T. R. Gilliland. (*Sci. News Letter*, 19th July 1941, Vol. 40, No. 3, p. 37.) *See* also another note on same page. The eruption was on 3rd July: signals from Toronto were still somewhat disturbed on 9th July.

2972. ON MAGNETIC DISTURBANCES IN THE IONOSPHERE.—N. D. Bulatov. (*Journ. of Tech. Phys.* [in Russian], No. 2, Vol. 10, 1940, pp. 133–141.)

A short survey of the work by the Ionosphere Station at Tomsk during 1936–1938, mainly concerned with observations of the critical frequency and height of the F layers. Diagrams are plotted from which the following main conclusions are derived:—(1) In addition to the 11-year periodic change in magnetic conditions due to solar activity, there exists also a cycle of magnetic storms with a period of about 88 days. (2) The effect of magnetic storms on the ionisation of the F layer is particularly noticeable during the night and morning. The rise in the critical frequency of the F layer due to this effect makes conditions at night more similar to those during daylight (communication on the 20 m band becomes possible).

2973. SHORT-WAVE RADIO TRANSMISSION AND GEOMAGNETISM [RCAC Circuit-Disturbance Ratings compared with "K Index" Ratings (1010 of April): Correlation of London "GLH" Signal (during Disturbed Month, April 1936) with Earth-Current Trace Variability: Inverse-Variability Law is a Fair Mean (neglecting Post-Storm Days): Application to Calculation of Necessary Powers: Pronounced "Knee" in Curve of Interruptions, at 50° N: etc.].—H. E. Hallborg. (*R.C.A. Review*, April 1941, Vol. 5, No. 4, pp. 395–408.)

"Fig. 9 illustrates one of the most exciting solar rotations in short-wave history" [17th March/12th April, 1940]. Fig. 10 includes "one anomaly, the first to come to the author's attention, namely the association of excellent signal conditions in the face of considerable magnetic disturbance during the first 4 or 5 days of the sequence beginning 30th July 1940."

2974. PHENOMENA OF PHOTOPHORESIS AND SPECIAL APPLICATION FOR THE SYSTEM SUN-EARTH [including Influence of Sunspot Cycle, Cause of Earth's Magnetism, etc.], *and* PHOTOPHORESIS: APPLICATIONS AND THE QUESTION OF THE EXISTENCE OF UNIPOLAR MAGNETISM.—L. Banet: F. Ehrenhaft. (*Phys. Review*, 15th July 1941, Vol. 60, No. 2, p. 169: p. 169: summaries only.) *See* also 11 of January.

2975. MOTION OF THE EARTH'S FLUID CORE: A GEOPHYSICAL PROBLEM [including the Diurnal Variation of the Earth's Magnetism].—D. R. Inglis. (*Phys. Review*, 15th Jan. 1941, Vol. 59, No. 2, pp. 178–188.) For previous work *see* 3322 (and 3321) of 1940.

2976. "ANNUAL REPORT OF THE DIRECTOR OF THE DEPARTMENT OF TERRESTRIAL MAGNETISM" [Book Review].—Carnegie Institution. (*Engineering*, 15th Aug. 1941, Vol. 152, p. 123.)

2977. CHARLES CHREE AND HIS WORK ON GEOMAGNETISM [Address to Physical Society].—S. Chapman. (*Nature*, 9th Aug. 1941, Vol. 148, pp. 153–157.)

2978. LATITUDE EFFECT OF COSMIC RAYS ABOVE 50° N LATITUDE [and the Cause of the "Cut-Off"].—P. F. Gast & D. H. Loughridge. (*Phys. Review*, 15th Jan. 1941, Vol. 59, No. 2, pp. 127–129.)

See also 2874 of 1940. "Thus the 'cut-off' appears to be caused, at least in part, by a magnetic effect, external to the earth, which experiences changes at the time of magnetic storms": supporting Vallarta's suggestion of action of sun's magnetic field (*Nature*, 1937: *see* also 1342 of 1940).

2979. EFFECT OF THE TOTAL ECLIPSE OF THE SUN OF 1ST OCT. 1940 ON THE INTENSITY OF THE COSMIC RADIATION [Increase of 12–15% during Eclipse, with Possible Error of 2%: at San Paulo].—G. Occhialini & M. D. de S. Santos. (*La Ricerca Scient.*, Oct. 1940, Vol. 11, No. 10, p. 792.) For a preliminary announcement *see* 2063 of August.

2980. The Thundercloud as a Source of Penetrating Particles.—Halliday. (*See* 3002.)

2981. Extensive Cosmic-Ray Showers and the Energy Distribution of Primary Cosmic Rays [Measurements from Sea Level up to 4300 Metres: Approximate Formula presumably representing Energy Distribution of Primary Protons in Range 10^{16} to 10^{10} eV].—N. Hilberry. (*Phys. Review*, 1st July 1941, Vol. 60, No. 1, pp. 1–9.)

2982. Nuclear Particles in the Cosmic Radiation [Rate of Production of Protons found to be of Same Order as That of Neutrons].—S. A. Korff. (*Phys. Review*, 15th June 1941, Vol. 59, No. 12, pp. 949–954.)

"The energy distribution, the amount of the flux and the altitude dependence suggest that both protons and neutrons are produced about equally by a process or processes connected with the soft component of the radiation." *See* also "Fast Neutrons and Particles with High Specific Ionisation in the Cosmic Radiation at High Elevations," *ibid.*, 15th Jan. 1941, No. 2, p. 214.

2983. On the Ratio of Intensity of the Electronic and Mesotronic Components [of the Cosmic Radiation, measured in the Open Air and below Ground].—M. Santangelo & E. Scrocco. (*La Ricerca Scient.*, Sept. 1940, Vol. 11, No. 9, pp. 601–604.) For further work *see* Dec. issue, No. 12, pp. 952–956.

2984. Nucleus Destruction and Heavy Particles in the Cosmic Radiation: Part I—The Heavy Particles in the Cosmic Radiation as the Result of Nucleus Destruction: Part II—The Course of the Collision and Vaporisation Processes.—E. Bagge. (*Ann. der Physik*, 31st May 1941, Vol. 39, No. 6/7, pp. 512–534 & 535–552.)

2985. Cloud Tracks of Cosmic Rays in the Substratosphere, *and* Cloud-Chamber Pictures of Cosmic Rays at 29 000 Feet Altitude.—G. Herzog: G. Herzog & W. H. Bostick. (*Phys. Review*, 15th Jan. 1941, Vol. 59, No. 2, pp. 117–122: pp. 122–126.)

2986. Ultra-Violet Rays and Their Variations [Observations by Method approximately eliminating Effect of Lower Atmosphere (using Ratio of Values of Ultra-Violet Band & Visible Band): Variation in Sympathy with Solar Cycle: Variation with High Values in Winter and Low in Summer: Variation with High Values at Sunrise & Sunset and Low at Midday: Explanation as Logical Converse of Variations in Kennelly-Heaviside Layer Ionisation].—J. R. Ashworth. (*Nature*, 23rd Aug. 1941, Vol. 148, pp. 225–226.)

2987. Global Solar Radiation at Trieste, 1934/1939.—S. Polli. (*La Ricerca Scient.*, Oct. 1940, Vol. 11, No. 10, pp. 706–710.)

2988. An "Ultra-Spectrometer" Technique for Infra-Red Absorption Bands [and the Effect of Total Pressure on Ozone Absorption].—M. Summerfield & J. Strong. (*Phys. Review*, 15th Jan. 1941, Vol. 59, No. 2, pp. 217–218: summary only.) *See* also back reference in 1609 of June, and *Phys. Review*, 15th July 1941, Vol. 60, No. 2, p. 162.

2989. Study of Atmospheric Absorption and Emission in the Infra-Red Spectrum.—J. Strong. (*Journ. Franklin Inst.*, July 1941, Vol. 232, No. 1, pp. 1–22.) For other recent work by the same writer *see* 1152 & 3299 of 1940, and 1297 of May.

2990. Heights and Velocities of Meteors.—H. C. Plummer. (*Sci. Abstracts*, Sec. A, July 1941, Vol. 44, No. 523, p. 178.)

2991. On the Differential Equations of Wave Propagation in Gases.—K. Bechert. (*Ann. der Physik*, 4th May 1941, Vol. 39, No. 5, pp. 357–372.) For previous work *see* 2361 of September.

2992. A New Calculus for the Treatment of Optical Systems [containing an Anisotropic Absorber, Optically Active Solution, etc.]: Part I—Description and Discussion of the Calculus: Part II—Proof of Three General Equivalence Theorems: Part III—The Sohncke Theory of Optical Activity].—R. Clark Jones, H. Hurwitz, Jr. (*Journ. Opt. Soc. Am.*, July 1941, Vol. 31, No. 7, pp. 488–503.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

2993. Wave Form of Atmospherics [Theory that "Slow Tail" represents Radiation resulting from Destruction of Electric Moment during *a* and *c* Portions of Lightning Stroke].—C. E. R. Bruce. (*Nature*, 9th Aug. 1941, Vol. 148, p. 165.) Fitting in with the writer's theory of the increasing corona current as leader stroke approaches the earth (2364 of September).

2994. The Validity of Lightning Tests with Scale Models.—R. H. Golde. (*Journ. I.E.E.*, April 1941, Vol. 88, Part II, No. 2, pp. 67–68.) E.R.A. Report Ref. S/T38.

2995. Errors of Observation due to Instrument-Scale Limitations [primarily in Lightning-Discharge Investigations, where Scatter Diagrams showing Variation with Distance of Field Changes are affected by Recording Apparatus missing All Records below a Certain Level: Other Examples].—R. H. Golde. (*Nature*, 16th Aug. 1941, Vol. 148, pp. 196–197.)

2996. The Measurement of Lightning Voltages and Currents in South Africa and Nigeria, 1935 to 1937.—F. R. Perry. (*Journ. I.E.E.*, April 1941, Vol. 88, Part II, No. 2, pp. 69–87.)

2997. Earth's Crust Resistance and Lightning.—A. S. Runciman. (*Sci. Abstracts*, Sec. B, July 1941, Vol. 44, No. 523, pp. 129–130.)

2998. Motor-Cars and Lightning [Westinghouse Experiments.].—G. D. McCann. (*Engineer*, 22nd Aug. 1941, Vol. 172, p. 125.)

2999. "Surge Phenomena: Seven Years' Research for the Central Electricity Board, 1933/1940" [Book Review].—(*Engineering*, 12th Sept. 1941, Vol. 152, pp. 203–204.)

3000. New Theory of the Lightning-Discharge Current [Theory built up by Thermodynamic Reasoning, free from Unwarranted Assumptions of Previous Inadequate Theories].—R. Lundholm. (*Sci. Abstracts*, Sec. B, July 1941, Vol. 44, No. 523, p. 120.) Results appear to indicate that protection based on previous calculations is insufficient.

3001. Recommendations for Replacement, necessitated by the War, of Copper in the Construction of Lightning Conductors, *and* Proposed Recommendations for the Protection of Electrical Installations against Surges of Atmospheric Origin.—(*Bull. Assoc. suisse des Élec.*, 18th July 1941, Vol. 32, No. 14, pp. 334–335: pp. 335–344: in French.)

3002. The Thundercloud as a Source of Penetrating Particles [Cloud-Chamber Observations on 65 Thunderstorms: Strong Possibility of Ejection of Penetrating Particles & Arrival on Earth at Considerable Distances from Clouds: Evidence against Simple Theory of Magnetic Spiralling].—E. C. Halliday. (*Phys. Review*, 15th July 1941, Vol. 60, No. 2, pp. 101–106.) Further investigation of Wilson's suggestion: for the previous work *see* 1934 Abstracts, p. 316.

3003. The Resistivity of Interstellar Space [Letter on "Electric Fields produced by Cosmic Rays"].—F. L. Mohler: Foster Evans. (*Phys. Review*, 15th June 1941, Vol. 59, No. 12, p. 1043.) *See* 1312 of May.

3004. Are there Spin-One Mesotrons?, *and* On Secondary Slow Mesotrons [also, Indications of Slow Secondary Protons].—H. Snyder: V. I. Veksler & N. A. Dobrotin. (*Phys. Review*, 15th June 1941, Vol. 59, No. 12, p. 1043: pp. 1044–1045.)

3005. On the Theory of the Thermal Diffusion Coefficient for Isotopes: II.—Clark Jones. (*Phys. Review*, 15th June 1941, Vol. 59, No. 12, pp. 1019–1033.) For Chapman's recent paper, here referred to, *see* 701 of March.

PROPERTIES OF CIRCUITS

3006. The Radiation Resistance of Surfaces of Revolution, such as Cylinders, Spheres, and Cones [Mathematical Treatment with Results applicable to Many Problems (*e.g.* regarding Resonators for Ultra-Short Waves) when More Information is available on Charge Distribution].—E. B. Moullin. (*Journ. I.E.E.*, March 1941, Vol. 88, Part III, No. 1, pp. 50–58.)

Sequel to the paper dealt with in 2596 of 1936. It includes an appendix on the interpretation of L and C in the equation for the long line, and on the self-inductance of a hollow sphere. "Heaviside appears to have thought $\partial V/\partial x$ existed only because q varied with distance, whereas in fact it is also produced by a uniform charge variable in time . . ." For a short Discussion see *ibid.*, June 1941, Part III, No. 2, p. 171, where Page quotes from his paper referred to in 3042, below.

3007. Perturbation of Boundary Conditions [Method applicable to Resonators of Rhumbatron Type, etc.].—Feshbach & Clogston. (*See* 3168.)

3008. The Nature, Meaning, and Purpose of the Laplace Transformation: an Introduction for Communications Engineers [with Examples in Circuit & Line Problems].—H. Schulz. (*T.F.T.*, April, May, & Aug. 1940, Vol. 29, Nos. 4, 5, & 8: April & May 1941, Vol. 30, Nos. 4 & 5.)

3009. The Theory of the Synchronisation of Relaxation Auto-Oscillations.—L. P. Kholodenko. (*Journ. of Tech. Phys.* [in Russian], No. 2, Vol. 10, 1940, pp. 112–132.)

A short survey of the literature on the synchronisation of relaxation oscillations at the frequency of an external force is given, and using the mathematical theory of non-linear oscillations expounded by Koenigs and Lémeray an "idealised" case of a dynatron oscillator (Fig. 1) is discussed. It is shown that in the m-th region of synchronisation there are $2m$ periodical oscillations of which m are stable and m unstable (m is the number of the harmonic of the external e.m.f. at whose frequency synchronisation takes place). The effect of the number m and of the parameters of the oscillator on the width of the synchronisation regions is investigated, and it is shown that if the amplitudes of the external e.m.f. are not very large these regions do not overlap. The relationship between the "phase" of synchronised oscillations and the amount of detuning is discussed, and finally methods are indicated for determining the time required for synchronisation to be effected.

3010. The Regeneration of Oscillatory Circuits by Iron-Cored Chokes.—W. Taeger. (*Arch. f. Elektrot.*, 15th April 1941, Vol. 35, No. 4, pp. 193–216.)

Extension of the work dealt with in 50 of 1940 and back reference, and that of Erdelyi (1934 Abstracts, p. 436) and Kober (60 of 1939). "The quasi-harmonic treatment of the differential equation of the oscillatory circuit containing an iron-cored choke leads to interesting results regarding the self-exciting powers of such circuits." The condition for the setting-in of oscillation is analogous to that for iron-free circuits, with the difference that the form factor plays a rôle in determining the value of the permissible damping. "The technically most important case is doubtless that in which the positive and negative dampings cancel out; the frequency modulation then disappears, leaving a simple cosine oscillation together with a sine function which, however, soon disappears."

3011. Transient Processes in D.C./A.C. Inverters: Corrections.—J. Müller-Strobel. (*Arch. f. Elektrot.*, 15th April 1941, Vol. 35, No. 4, p. 258.) *See* 2380 of September.

3012. Papers on the Transmission of Noise Voltages by Various Types of Detector.—Fränz. (*See* 3026 & 3027.)

3013. Cascade Amplifiers with Maximal Flatness.—V. D. Landon. (*R.C.A. Review*, Jan. & April 1941, Vol. 5, Nos. 3 & 4, pp. 347–362 & 481–497.)

"The theory of the conventional constant-K filter is not very satisfactory from the engineering standpoint", being developed on the basis of terminations which match the surge impedance. This involves resistors varying with frequency, and when a compromise resistor is used an accurate calculation of performance becomes difficult: also, optimum flatness is not generally obtained. The present system's performance is easily calculated for any number of circuits, and the curve is the flattest obtainable with that number: the effect of component resistances is not neglected as in conventional theory.

3014. On the Optimum Shape of the Transmission Curves of Three-Circuit Broadcast Filters.—Gensel. (*See* 3025.)

3015. An Analysis of Constant-K Low- and High-Pass Filters [Method giving More Direct Approach than through Generalised Filter Theory: Complete Insertion Loss & Phase Shift as Functions of Frequency Ratios f/f_c & f_c/f, respectively].—O. S. Meixell. (*R.C.A. Review*, Jan. 1941, Vol. 5, No. 3, pp. 337–346.)

The filter is assumed to be terminated at both ends in a physical (or equivalent) resistance equal to the frequently used value of $\sqrt{L/C}$.

3016. A Vestigial Side-Band Filter for Use with a Television Transmitter.—Brown. (*See* 3088.)

3017. Quadripoles with Prescribed Attenuation Characteristics.—W. Cauer. (*T.F.T.*, July & Aug. 1940, Vol. 29, Nos. 7 & 8, pp. 185–192 & 228–235.)

"The problem dealt with here is to calculate quadripoles whose attenuation as a function of frequency is given in advance. This task is solved, to any desired approximation, for the general case where the attenuation in an interval (ω_1, ω_2) of the angular frequency ω is given as an arbitrary continuous function, only positive values being admitted in the case of the operative attenuation ("Betriebsdämpfung"). For reactance quadripoles, *i.e.* quadripoles having only inductances, mutual inductances, and capacitances, solutions are found for the operative attenuation as well as for the current, voltage, and open-circuit attenuations. The problem is also solved for the passive symmetrical quadripole of constant operative resistance containing ohmic resistances: here the operative attenuation coincides with the current and voltage attenuations.

"For the relation between the last-named circuits, and circuits with prescribed current or voltage attenuation with finite operative resistance or conductance, on the one hand, and separating filters of constant operative resistance on the other hand, and also for the design of further (*e.g.* chain-type) reactance quadripoles having the same attenuation as a first reactance quadripole, the following notable law obtained here is of interest:—'Every frequency function representable as an impedance can be realised as a dipole containing only one ohmic resistance, or (which comes to the same thing) as a reactance quadripole whose output is loaded with an ohmic resistance (*see* also 1627 of June). Filters, *i.e.* reactance quadripoles in which certain complete frequency intervals are specially allowed to pass and the complementary frequency intervals (except for narrow transition bands) are blocked, appear in this generalised theory only as a special case, in which the continuous curve has a particular course.'"

3018. The Application and Use of Quartz Crystals in Telecommunications.—C. F. Booth. (*Journ. I.E.E.*, June 1941, Vol. 88, Part III, No. 2, pp. 97–128: Discussion pp. 128–144.) Already referred to in 720 of March.

3019. The Properties of Quartz Oscillators and Resonators at Audio and Medium Frequencies.—Rohde & Handrek. (*See* 3112.)

TRANSMISSION

3020. Generation of Ultra-Short Waves [Voltage at Grid of Retarding-Field Valve, or Anode of Magnetron, made Higher than That corresponding to Permissible Loading: Load reduced by Periodic Interruption of Current by Grid close to Cathode].—J. Pintsch Laboratories. (*Hochf:tech. u. Elek: akus.*, May 1941, Vol. 57, No. 5, p. 139.) German Patent 697 455.

3021. A Transmitter for Frequency-Modulated Broadcast Service using a New Ultra-High-Frequency Tetrode [1 kW Transmitter with Crosby Method of F. M. Stabilisation: Type FM-1-B, using Two RCA-827R 500 W Beam Tetrodes].—A. K. Wing & J. E. Young. (*R.C.A. Review*, Jan. 1941, Vol. 5, No. 3, pp. 327–336.)

3022. Frequency Modulation [Short Generalised Theory and Bibliography].—Seeley. (*See* 3157.)

3023. The Use of Frequency Modulation in Broadcasting and Radio Communication in the U.S.A. [Discussion of F.C.C. Meeting of March 1940].—V. A. Smirnov. (*Elektrosvyaz* [in Russian], No. 1, 1941, pp. 5–17.) *Cf.*, for example, 2765 of 1940.

3024. A New Circuit for generating Alternating Electric Pulses of Very Short Duration [*e.g.* down to 0.0001 Second, 250–300 V Peak Value: Duration & Intensity controlled Independently.]—G. Potapenko. (*Phys. Review*, 15th Jan. 1941, Vol. 59, No. 2, pp. 220–221: summary only.)

RECEPTION

3025. On the Optimum Shape of the Transmission Curves of Three-Circuit Broadcast Filters.—J. Gensel. (*T.F.T.*, June 1940, Vol. 29, No. 6, pp. 159–164.)

Extending the work of Wucherer (3916 of 1939) in two points. Wucherer represented the transmission equivalent of such filters by a cubic parabola in the complex plane and specified the form of the three-hump resonance curves by two " form values " F_0 and F_1 of this parabola ; he assumed that the optimum over-all characteristic was one which was " balanced," that is, one in which all three humps were equally high, separated by equally deep troughs. He gave the pairs of " form values " for such a compensated filter and showed how they could be obtained by suitable choice of the circuit elements. The present writer first examines how far the actual " form values " may depart from the calculated values without causing the resonance curve to be too different from the ideal " balanced " form, so as to obtain an estimate of the necessary precision in constructing the filters. Then in the second part of his paper he shows that the " balanced " resonance curve is the best in practice in so far as it has the best filtering action for a given permissible distortion over a given frequency band : " the most favourable transmission curve is obtained if the prescribed maximum distortion is exploited as often as possible (*i.e.* in three-circuit filters by three humps) and as completely as possible (*i.e.* by equally high humps and by making $|ü_G| = |ü_T|$, where $ü_G$ and $ü_T$ are the transmission equivalents at the limiting frequency and at a trough, respectively. Whether this optimum transmission curve can actually be obtained in practice depends on the quality factor of the available coils."

3026. Contribution to the Calculation of the Signal-Voltage/Noise-Voltage Ratio at the Output Terminals of a Receiver.—K. Fränz. (*E.N.T.*, Oct. 1940, Vol. 17, No. 10, pp. 215–229.)

The paper referred to in the first paragraph of 3027, below. Assistance from two fields of mathematics is invoked : first, propositions on calculation with Fourier series and integrals, which are valid for all spectra of ordered and random processes ; secondly, a proposition (Markoff, von Laue) from statistics, with which to obtain the special properties of random noise processes. The transmission of a unit disturbance by way of a smooth, otherwise arbitrary, characteristic is dealt with. The spectra thus formed are the same as those occurring in the transmission of noise voltages by way of the same characteristic, with the difference that the average value of the Fourier spectrum cannot be calculated for noise voltages, since the average value in time of a component $f(n)$ is zero except when $n = 0$ (direct current) : the energy spectra must therefore be used.

Exact formulae, and approximations convenient for numerical calculation, are given for the unit-disturbance spectra (eqns. 32–35 and eqns. 40–42 : Figs. 3 and 4 : a comparison of the results obtained with the polynomial eqn. 32 and with the asymptotic expression eqn. 40 is given in the tables on p. 221). The mutual action of signal and noise is calculated, so that the signal/noise ratio can be obtained for the receiver output. In particular, it is thus possible to see the differences between the various types of transmission—telegraphy, telephony, etc.—and of detectors, as well as the influence of the distribution of the over-all selectivity between the i.f. and l.f. stages on the sensitivity. For reception of type A_1, the signal/noise ratio beyond the rectifier is equal to the value measured in the i.f. stage. It is the better, the smaller the added carrier. With the square-law rectifier it is $\sqrt{2}$ times better when the added carrier is removed completely : in the l.f. output stages no note corresponding to the signal is heard, but a relay working on effective values would function. This somewhat surprising $\sqrt{2}$ increase in sensitivity by the omission of the second heterodyne was confirmed experimentally with an anode-bend-detector receiver. " Whether the signal/noise ratio is actually, in all circumstances, a correct measure of the receptional merit of a signal must remain in abeyance." With small or vanishing added-carrier values, the signal/noise ratio is the better, the higher the power-law of the rectifier. With a large added carrier no sensitivity can be gained by note selection, if the band width has already been limited in the i.f. stages to that required by the signal breadth. If the added carrier lies outside the i.f., the distribution of the over-all selectivity between the i.f. and l.f. has no influence on the sensitivity : otherwise, a $\sqrt{2}$ loss can be suffered if most of the selectivity is kept for the l.f. stages. The same applies to the mixing process in the first heterodyne, the h.f. and i.f. here bearing the same relations to each other as the i.f. and l.f. considered above.

For reception of A_2 and A_3 types the results are the same as for the A_1 type so long as the signal contains a carrier which predominates over the noise ; but important differences occur when the signal decreases in comparison with the noise, or when (in type A_2 reception) the carrier is keyed. In such cases the i.f. selectivity must be pushed as high as possible ; l.f. selectivity brings a small additional advantage, which however is generally not worth considering. The higher the power-law of the detector, the better the signal/noise ratio.

In the final section the work of previous writers is considered. For example, Strafford's square-law-detector results (2530 of 1937) on the noise without added carrier are approved : his calculations of effective values with added carrier are stated to be incorrect, for reasons given. Williams (1364 of 1937) obtained by a different method correct results for the square-law detector, but did not deal in detail with the spectral distribution of noise. No one seems to have dealt thoroughly with the noise voltages after rectification with laws higher than the second power.

3027. The Transmission of Noise Voltages by the Linear Rectifier.—K. Fränz. (*Hochf : tech. u. Elek : akus.*, June 1941, Vol. 57, No. 6, pp. 146–151.)

From the Telefunken laboratories. The study of the influence of the non-linear part of receiving circuits has been impeded by the mathematical difficulties associated with all non-linear problems. The matter is of importance in connection with demodulation, mixing, and reversals such as occur in target-flight receivers for aircraft. For the non-linear characteristic which can be represented by a power series, satisfactory methods have recently been developed for the exact discussion of such questions; how, for instance, the distribution of the over-all selectivity of a receiver between the i.f. and l.f. stages affects the signal/noise ratio at the output, or what the effect is if square-law detection is changed to detection of a higher order (Fränz, 3026, above). But it is just the technically interesting "linear" detector with its bent characteristic, unrepresentable by a uniform analytical function, that cannot, in principle, be dealt with in this way. It is true that as regards sensitivity no great difference would be expected between a linear and a quadratic rectifier, since in actual practice the curves are smooth enough to come under the same treatment as the others. But the special properties of the nearly linear detector of practice can best be seen if it is assigned an ideal "kneed" characteristic, and it is therefore desirable to develop suitable methods for the quantitative discussion of its behaviour towards noise voltages.

Author's summary:—"A method for calculating the effect of bent characteristic curves on the transmission of noise voltages is developed and applied to answer two technically interesting questions: can a linear detector be used for the measurement of signal and noise voltages, and how does the spectral distribution of the noise energy following the linear detector differ from that following the square-law detector? For the first problem a calibration curve is calculated; for the second, the spectral energy distribution, which is seen to differ very little from that given by the square-law detector."

3028. The Measurement of Interference at Ultra-High Frequencies [25–150 Mc/s: Examination of Operation of Frequency-Changers, and the Special Suitability of the Electron-Coupled Mixer for U.H.F. Interference Measurements: Design & Performance of Measuring Set, on Principles deduced, usable both for Field-Strength & Voltage Measurements].—L. H. Daniel & G. Mole. (*Journ. I.E.E.*, March 1941, Vol. 88, Part III, No. 1, pp. 41–49.)

3029. Cutting Out Interference [Blocking Bias obtained in Part from R. F. Side (proportional to Mean Carrier Amplitude) & in Part from A.F. Side (follows Fluctuations of Modulation Envelope)].—Magyar Wolframlampa. (*Wireless World*, Sept. 1941, Vol. 47, No. 9, p. 246: British Patent.)

3030. Suppression of Interference Peaks [while passing Modulation Peaks up to 100%, by setting Limiter by Bias derived from Audio Signal Voltage fed back through Delay Network].—H. A. Fairhurst. (In short Discussion of paper dealt with in 3086, below.)

3031. Proposed Federal Order for the Limitation of Interference by Low-Power Electrical Apparatus [Danger of setting Too Low a Limit on Max. Interfering Voltage: Suitability of 1 mV as This Value: etc.].—(*Bull. Assoc. suisse des Élec.*, 18th July 1941, Vol. 32, No. 14, pp. 333–334: in French.)

3032. Some Aspects of Interference with Radio Reception [International Committee's Definition of Upper Limit: Australian Experience: Suppression Methods at Source & at Receiver].—J. C. J. McGuiness. (*Journ. Inst. Eng. Australia*, May 1941, Vol. 13, No. 5, pp. 126–127: summary only.)

3033. Contributions on the Screening Action of Coverings against Leakage Fields of 50 c/s Alternating Current.—Schadwinkel. (*See* 3153.)

3034. Broadcast Receivers: a Review.—N. M. Rust, O. E. Keall, J. F. Ramsay, & K. R. Sturley. (*Journ. I.E.E.*, June 1941, Vol. 88, Part III, No. 2, pp. 59–90: Discussion pp. 90–96.) Already dealt with in 1350 & 1351 of May.

3035. Designing a Modern Superheterodyne: Three-Valve Reflex Circuit with "Forward and Backward" AVC.—R. G. D. Holmes. (*Wireless World*, Sept. & Oct. 1941, Vol. 47, Nos. 9 & 10, pp. 224–227 & 261–262.)

3036. Wireless in Canada [Data on Sales of Receivers, etc.].—(*Electrician*, 12th Sept. 1941, Vol. 127, p. 148: paragraph only.)

AERIALS AND AERIAL SYSTEMS

3037. The Radiation Resistance of Surfaces of Revolution, such as Cylinders, Spheres, and Cones.—Moullin. (*See* 3006.)

3038. Wave Guides [Survey, including Writer's Radiation Patterns of Horizontally Flared Horn].—Houldin. (*See* 2959.)

3039. Measurements on Dipoles in the Decimetric-Wave Region [Results applicable to Other Wavelengths].—P. Lange. (*Telefunken-Mitteil.*, May 1940, Vol. 21, No. 83, p. 72 onwards: summary in *Bull. Assoc. suisse des Élec.*, 18th July 1941, Vol. 32, No. 14, pp. 324–326: in German.)

"For many purposes it is important to know the resistance of a horizontal dipole excited at a current antinode, and its dependence on the dimensions of the dipole and its distance from conducting ground. The theory of such dipoles in free space, or with a reflecting, infinitely extended plane, is known on the assumption that the dipole is infinitely thin. The use of decimetric waves allows the theory to be tested on a reduced scale." The resistance measurements were carried out with the help of a Lecher pair closed at one end by the unknown resistance $\mathfrak{R}$ and excited at the other end by a signal generator. The ratio $\mathfrak{R}/Z$ (Z being the characteristic impedance of the Lecher pair) is given by the telegraphy equation involving n, the ratio of the max. to min. amplitudes of the standing waves formed on the pair, and $\tan \alpha x$, where $\alpha = 2\pi/\lambda$ and x is the distance of the first potential minimum from the terminating resistance $\mathfrak{R}$ at the end of the Lecher pair.

A four-slit magnetron serves as the generator. The Lecher pair is built to be very rigid, the wires being 10 mm thick and 1 m long, with a centre-to-centre spacing of 20 mm: the pair is screened by a brass tube of 66 mm internal diameter with a slit along the top, and the whole is made fast by Trolitul discs screwed in near the ends. The equivalent reactance of the parallel capacity formed by these discs is measured (Fig. 2 and adjacent text). The characteristic impedance of the Lecher pair (assumed to be free from losses) is calculated from its geometrical dimensions and found to be about 140 ohms. The potential distribution along the pair is measured by a special exploring device sliding over the slit in the screening tube. It consists of a low-loss $\lambda/4$ circuit with high input impedance, made up of the parts T, G, B and the short-circuiting plate E, together with the tuning condenser C (Fig. 1); T being a double exploring probe just entering the slit and forming a very loose coupling with the Lecher wires. The sliding device carries also a diode with its coupling loop D: the diode current, owing to the linear characteristic, serves as a direct measure of the h.f. potential. The Lecher pair is tested with its end short-circuited: if carefully constructed, it should then give equal potential maxima, as is actually found (Fig. 4) to be the case.

For accurate work the dipole under examination must be screened from the Lecher pair, and since the dipole must be at a certain distance from the screen (which must be considered also to be a reflecting plane) it is necessary, if the dipole is to be excited at a current antinode, to introduce between dipole and Lecher pair a screened feeder line whose length must be a multiple of $\lambda/2$ (seen at left of Fig. 3): the reactance effect of the junction is allowed for in the same way as was done for the Trolitul discs. A section through junction, feeder, screen, and dipole is seen in Fig. 5: the feeder must be fixed by two supports so arranged (at points determined graphically) that their effects cancel out. The screening tube of the feeder is not allowed to reach to the dipole: the correct gap is found by replacing the dipole by a carbon resistance and withdrawing the end of the tube until the measured real component of the resistance becomes constant.

Fig. 6 shows the measured dissipative and reactive components of the resistance of a 25 cm-long, accurately half-wave dipole, as functions of the distance from a plane reflector: each resistance tends, with increasing distance, towards a limiting value which the writer terms the "core resistance." Fig. 7 shows similar curves for various dipole lengths but the same 50 cm wavelength: the resonance length of the dipole (zero reactive component) is seen to be slightly shorter than the half-wavelength: "this phenomenon was found theoretically by Ruprecht for radiators in free space." Further measurements were made with cylindrical and parabolic reflectors: they brought out the fact that the resistance depends very little on the aperture of the reflector, whereas the radiation diagram depends very much on it. On the other hand, the radiation diagram is little affected by the distance and length of the dipole. The resistance of a dipole can therefore be varied within certain limits without altering the radiation diagram, which is useful in practice. "The value of the above investigations lies in the possibility of matching the feeders to the dipoles, for which the dipole resistance must be known. By expressing all lengths as 'relative' (dipole-length/wavelength) the results can be applied to all wavelengths."

3040. DISCUSSION ON TRENDS IN SHORT-WAVE DIRECTIVE AERIAL DESIGN [Rhombic *versus* Multi-Dipole Controversy].—L. A. Kopytin & others. (*Elektrosvyaz* [in Russian], No. 9, 1940, p. 79: No. 1, 1941, pp. 78 & 79–80.) Letters prompted by an editorial invitation to specialists to give their views.

3041. COMBINATION ANTENNA SYSTEM [Dipole, with Provision for Tilt & Swing, and Selector Transformers (U.H.F. Iron Cores) mounted on Mast for feeding Transmission Line (up to & over 100 Feet)].—Technical Appliance. (*Review Scient. Instr.*, July 1941, Vol. 12, No. 7, p. 373.)

3042. THE DESIGN OF RING AERIAL SYSTEMS FOR BROADCASTING [University of Manchester Thesis: including Expression for Radiation Resistance of Cylinder of Height Small compared with Wavelength].—H. Page. (*See* Moullin, 3006, above.)

3043. EARTH'S CRUST RESISTANCE AND LIGHTNING.—A. S. Runciman. (*Sci. Abstracts*, Sec. B, July 1941, Vol. 44, No. 523, pp. 129–130.)

VALVES AND THERMIONICS

3044. DEFLECTION AND IMPEDANCE OF ELECTRON BEAMS AT [Ultra-] HIGH FREQUENCIES IN THE PRESENCE OF A MAGNETIC FIELD [in Connection with Design of Deflection-Type Amplifiers & Oscillators: Addition of Magnetic Field (parallel to Plates) decreases Deflection but gives Lower Electron Loading for Same Deflection-Sensitivity].—L. Malter. (*R.C.A. Review*, April 1941, Vol. 5, No. 4, pp. 439–454.)

3045. ELECTROBALLISTIC MEASURING METHOD FOR THE CONSTRUCTION OF ELECTRON PATHS IN A ROTATIONALLY SYMMETRICAL MAGNETIC FIELD.—Sándor. (*See* 3123.)

3046. THE EFFECT OF A MAGNETIC FIELD ON THE SPACE CHARGE IN PLANE AND CYLINDRICAL DIODES: PART I.—S. Ya. Braude. (*Journ. Tech. Phys.* [in Russian], No. 3, Vol. 10, 1940, pp. 217–236.)

In this part of the paper the operation of a plane magnetron is discussed and equations are derived determining, for given values of the magnetic field H, the anode voltage V_a, and the parameter k determined from equation 101 ($\beta = (1 - k)/k \,.\, \alpha T$: the physical meaning of this parameter will be discussed in Part II), and also for various operating conditions, the following information:—(a) distribution of potential, (b) distribution of potential gradient, (c) wavelength of oscillations, (e) length of electron trajectory, and (f) density of electron stream ("rotating current"). The operation of a cylindrical (whole-anode) magnetron will be considered in Part II.

3047. PAPER ON FREQUENCY CONVERSION IN RELATION TO INTERFERENCE [and the Advantages of Electron-Coupled Mixers for U.H.F. Measurements].—Daniel & Mole. (In paper dealt with in 3028, above.)

3048. THE RCA-827R BEAM TETRODE IN A 1 KW FREQUENCY - MODULATED BROADCASTING TRANSMITTER.—Wing & Young. (*See* 3021.)

3049. THE FLUCTUATIONS OF SPACE-CHARGE-LIMITED CURRENTS IN DIODES [Experimental Determination of Reduction Ratio "A" for Cylindrical Diodes, & Discussion of Results: Fluctuations in Magnetron Diodes].—F. C. Williams. (*Journ. I.E.E.*, May 1941, Vol. 88, Part I, No. 5, pp. 202–204: summary of paper appearing in Part III in December.)

3050. FLUCTUATIONS IN SPACE-CHARGE-LIMITED CURRENTS AT MODERATELY HIGH FREQUENCIES: PART IV—FLUCTUATIONS CAUSED BY COLLISION IONISATION: PART V—FLUCTUATIONS IN VACUUM TUBE AMPLIFIERS AND INPUT SYSTEMS.—B. J. Thompson, D. O. North, W. A. Harris. (*R.C.A. Review*, Jan. & April 1941, Vol. 5, Nos. 3 & 4, pp. 371–388 & 505–524.)

Continued from 769 of March. (1) " Both calculation and measurement suggest that the ionisation component of noise may generally be ignored when the grid gas-current is less than a few hundredths of a microampere". (2) Including formulae, based on analysis in preceding parts, for noise-equivalent resistance values, arranged for use with published valve data: formulae for n.e. conductance values applicable to photoelectric cells and television pick-ups: applications to radio-receiver measurements (definition of " ensi "—equivalent noise sideband input): etc.

3051. " ELECTRIC AND MAGNETIC FIELDS " [including Shielding, Valve Design, & Tables of Statistical Data: Book Review.]—S. S. Attwood. (*Journ. Franklin Inst.*, July 1941, Vol. 232, No. 1, p. 95.)

3052. THE DEVELOPMENT OF WIRELESS TRANSMITTING VALVES [Chairman's Address to Wireless Section].—W. J. Picken. (*Journ. I.E.E.*, March 1941, Vol. 88, Part III, No. 1, pp. 2–10.)

3053. " ELEKTRONENRÖHREN ALS ANFANGSSTUFEN-VERSTÄRKER: ALS END- UND SENDER-VERSTÄRKER " [Book Reviews].—H. Rothe & W. Kleen. (*Hochf:tech. u. Elek:akus.*, May 1941, Vol. 57, No. 5, p. 142.) Vols. 3 & 4 of Zenneck's series (*see* 2721 of October).

3054. CONTRIBUTION TO THE QUESTION OF THE SECONDARY EMISSION FROM SUBLIMATED ALKALINE-EARTH FILMS.—P. Görlich. (*Physik. Zeitschr.*, 15th June 1941, Vol. 42, No. 7/8, pp. 129–133.)

Copeland (3047 of 1935) found that with the increasing thickness of a Ca layer, deposited on a gold base, the s.e. coefficient δ increased: he obtained values as high as 5. Similar behaviour was found for Li on Ta. As opposed to this, Chlebnikov found that δ decreased with increasing thickness of a Be layer on outgassed Ta (1070 of 1939), from a maximum of only 1.4 down to 0.55; Kollath obtained similar values for Be on Be and on Mo, the bases not being outgassed (156 of 1939 [also 1541 & 1892 of 1938]). Both Copeland and Kollath deduced an effect due to the base; the former concluded that the value of δ depended, for low-velocity primary electrons, chiefly on the sublimated top film, but for high-velocity electrons chiefly on the lower layer. Warnecke & Lortie (1927 of 1939 [and 1542 of 1938]), using Be on Ag, Ni, and other metals, also found an effect of the base: they pointed out that the Be layers were thicker than the penetration depth of the primary electrons, and maintained that, contrary to Copeland's ideas, even when the primary electrons failed to reach the lower layer the processes in the top film were influenced by the base. Weiss (3496 of 1936 [and 1470 of 1937]) found a dependence of δ on the base also for Cs_2O cathodes. For sublimated films of the alkalis and alkaline earths, various workers found that the secondary emission, like the external photoelectric effect, passed through a maximum as the alkali-film thickness increased (Afanesjeva & Timofeev, 2888 of 1938; Treloar, 3793 of 1937; Bruining & de Boer, 2971 of 1937 [and 982 of 1938]): these results disagree with those of Copeland and Chlebnikov, and the present writer therefore considered it desirable to decide by experiment what the curve for the dependence of secondary emission on the thickness of alkaline-earth sublimated layers actually is. In this question are involved also the influence on secondary emission exerted by the structure of the emitting layer and by the presence of a chemically active gas (*see* for example Schnitger, 2718 of October).

Author's summary:—" It is shown that it is possible to sensitise alkaline-earth sublimated films on metal bases by h.f. glow discharges in an inert gas. The most probable interpretation of this seems to be a structural change in the film. The measurement of secondary emission as a function of the film thickness shows that the secondary emission passes through a maximum as the thickness of the alkali film is increased. It cannot, however, be deduced from this that the secondary emission depends primarily on the work function " [such a conclusion, in agreement with Treloar, would mean that the secondary emission varied with the work function in the same way as the photocurrent in the external photoeffect: implying that the secondary emission occurred under the same conditions as photoelectric emission. But not only is it found that Ca films give a smaller photoelectric sensitivity in the inert-gas glow discharge, in contrast to the s.e. output, but a further experiment (described in the final paragraph) supports the s.e. mechanism suggested by Bruining & de Boer, in which the work function is not predominant: Kollath's work on Be alloys (not photosensitive but with high s.e. powers) also shows that photoeffect and secondary emission are not linked (2717 of October)].

3055. SECONDARY-ELECTRON EMISSION FROM SINGLE CRYSTALS OF COPPER, FOR SMALL PRIMARY-ELECTRON VELOCITIES.—G. Bekow. (*Physik. Zeitschr.*, 15th June 1941, Vol. 42, No. 7/8, pp. 144–145.)

A preliminary communication. The establishment of the dependence of field emission on the position of the emitting surface with respect to the crystal lattice (a dependence obviously connected with differing work functions of the various crystal planes), combined with the discovery that secondary-emission output varies with crystalline structure, suggests that secondary emission also may be influenced by the orientation of the emitting surface in the crystal lattice. The writer has now made measurements of the s.e. output from single crystals of copper, and has found that the output varies for different cuts: it is highest for the (100) plane (top curve), the two lower, broken curves were given by two cuts oblique to the lattice, and between these the full-line curve is that for a polycrystalline surface.

3056. Secondary Electrons from Semiconductors with Marked Photoelectric Properties.—H. Wolff. (*Ann. der Physik*, 14th June 1941, Vol. 39, No. 8, pp. 591–603.)

The secondary-emission property in conductors and non-conductors has been investigated very fully, without any clear elucidation of the process being attained. On the whole it can be said that the emission, whether produced by electrons or by other rays, for clean surfaces assumes no very large values, is very similar in its dependence on the primary energy, and is almost the same as regards the velocity distribution of the secondary electrons. The present work has as its purpose the investigation of secondary emission from substances which display a marked internal photoeffect, since it seems not impossible that such properties might show themselves also in certain peculiarities of the secondary radiation. Selenium was an obvious choice, and since this is a substance which approaches an insulator, it seemed desirable to examine also the influence of insulating power on the results, by preliminary measurements on a specially good insulator, quartz.

The apparatus employed (Fig. 1) enabled the dependence of the secondary-electron emission on the velocity of the primary electrons to be measured for the range 50–1000 volts, and also the velocity distribution of the secondary electrons, for various primary velocities. The preliminary tests on quartz coated with platinum showed that the effect of charging-up could be compensated by a negative auxiliary potential, so that the s.e. factor n, defined on p. 593 as $1 + I_2/(|I_1 + I_2|)$, could be measured accurately. Selenium in various modifications was then tested, and also selenium photocells in which the proportional thicknesses of the metallic coating layer (gold in two cases) were known. The curves for n as a function of primary energy (Fig. 3) differ in their shape for the various modifications of selenium; a comparison shows that selenium sputtered from the glassy modification is deposited as the black (photoelectrically inactive) variety. The influence of increasing thickness of the metallic coating layer was systematically followed: in addition to increasing the emitting power (until the thickness exceeded a certain value) it produced a steady transition from the selenium characteristic to that of gold. The relative velocity distribution was about the same for all the layers examined and for all primary energies. There was no clear evidence of any influence of photoelectric properties either on the emissive power or on the velocity distribution.

Finally, various cadmium-selenide phosphors were investigated. In spite of their otherwise different qualities these all behaved similarly under electron bombardment: differences at first observed between varieties with different conductivities were traced to charging-up effects and disappeared when the negative auxiliary potential was applied (Fig. 8). The heat treatment of the base material was found to produce greater effects than the amount of copper content in the phosphors. The velocity-distribution curves of all the layers were very similar.

3057. The Effect of Temperature on the Secondary Electron Emission from Nickel [Results with 1000 eV Helium Ions agree with Wooldridge's Measurements with 160 eV Electrons (4286 of 1940)].—Healea & Houtermans. (*Phys. Review*, 15th July 1941, Vol. 60, No. 2, p. 154.)

3058. Papers on Secondary Emission.—Timofeev & others. (*See* under " Phototelegraphy & Television ".)

3059. The Extraction of Electrons from Cold Metals at High Field Strengths [Survey, including Significance in Breakdown Phenomena].—Jackson & Chester. (*See* 3148.)

3060. Measurement of Cathode Emission by Use of the Electron Microscope [Application of Photographic Intensity-Measurement Technique to obtain Quantitative Measurements on Ba, Sr, & Ca Oxides: Time-Lapse Exposures allow Activation Processes to be observed in Detail: Ba Compounds other than Oxide].—G. W. Fox & F. M. Bailey. (*Phys. Review*, 15th Jan. 1941, Vol. 59, No. 2, pp. 174–178.)

3061. The Deposition of Oxide Coating by Cataphoresis [Production of Suspensions of Alkaline-Earth Carbonates having Advantages of Colloidal Suspensions: Particles can be deposited Cataphoretically though Size is ½ to 100 Microns].—M. Benjamin & A. B. Osborn. (*G.E.C. Journal*, Feb. 1941, Vol. 11, No. 3, p. 218: summary only.)

3062. A New Technique for preparing Monocrystalline Metal Surfaces for Work Function Study. The Work Function of Ag(100).—P. A. Anderson. (*Phys. Review*, 15th June 1941, Vol. 59, No. 12, pp. 1034–1041.) *Cf.* 2173 of August.

3063. Preparation of Tungsten Single Crystal Faces for Thermionic Emission Studies.—A. A. Brown. (*Phys. Review*, 15th July 1941, Vol. 60, No. 2, p. 170: summary only.)

3064. Potentiometer Type of Optical Pyrometer [for Steel Mills, etc: also for Precision Measurements on Filament & Hot-Wire Temperatures, etc].—Leeds & Northrup. (*Review Scient. Instr.*, July 1941, Vol. 12, No. 7, p. 372.)

DIRECTIONAL WIRELESS

3065. Interlocked-Signal Beacon with Central Uninterrupted-Note Beam.— Standard Telephones & Cables. (*Wireless World*, Sept. 1941, Vol. 47, No. 9, p. 246 : British Patent.)

3066. Elimination of Night Error [by Completely Closed Loop divided into Two Halves by Vertical Conductor (coupled to Receiver) whose Antenna Effect is Neutralised by Differential Condenser to Earth].—R. Hell. (*Hochf : tech. u. Elek : akus.*, May 1941, Vol. 57, No. 5, p. 141.) German Patent 699 680.

3067. Radio Altimeter [Confusion & Ambiguity of Beat Note, at Points of Change from Increasing to Decreasing Altitude, avoided by giving Saw-Tooth (Wobble-Control) Oscillations One Vertical & One Inclined Flank].—B. J. Witt. (*Wireless World*, Sept. 1941, Vol. 47, No. 9, p. 246.) Patent assigned to Marconi Company.

3068. Barometric Height Measurement in Aviation [with Analysis of Errors].—K. Ramsayer. (*Zeitschr. f. Instr:kunde*, June 1941, Vol. 61, No. 6, pp. 196–197 : summary only.)

3069. Effects of Motion of Aeroplane in Neighbourhood of a Short-Wave Receiving Aerial.—Grosskopf & Vogt. (*See* 2963.)

ACOUSTICS AND AUDIO-FREQUENCIES

3070. Perturbation of Boundary Conditions [Method applicable to Room Acoustics, etc.].—Feshbach & Clogston. (*See* 3168.)

3071. Acoustics of Cinema Auditoria [Investigations to discover Reasons for Difference of Performance in Sound Reproduction by Identical Equipment in Apparently Similar Cinemas].—C. A. Mason & J. Moir. (*Journ. I.E.E.*, Sept. 1941, Vol. 88, Part III, No. 3, pp. 175–186 : Discussion pp. 186–190.) Referred to in 795 of March.

3072. Acoustic Filtration in Parallel-Conduit Structures [Theoretical & Experimental Investigation].—L. W. Labaw. (*Phys. Review*, 15th July 1941, Vol. 60, No. 2, p. 171 : summary only.)

"By varying the dimensions of the conduits, nearly any frequency region up to 10 000 c/s may be attenuated."

3073. The Properties of Quartz Oscillators and Resonators at Audio and Medium Frequencies.— Rohde & Handrek. (*See* 3112.)

3074. Solid Iris Diaphragms [for Sound Resonators, etc.].—R. S. Clay. (*Journ. of Scient. Instr.*, Sept. 1941, Vol. 18, No. 9, pp. 190–191.)

3075. A New High-Quality Soundhead [with "Shock-Proof Drive," etc.].—R. H. Heacock. (*R.C.A. Review*, Jan. 1941, Vol. 5, No. 3, pp. 283–292.)

3076. The Measurement of the Frequency of the Tuning Note [La_3] during a Musical Performance [Survey, leading to Description of INEA Apparatus for the Automatic Recording of the Required Frequency with Great Rapidity & Precision].—A. Barone. (*La Ricerca Scient.*, Dec. 1940, Vol. 11, No. 12, pp. 961–972.)

3077. On a Magneto-Acoustic Effect [Velocity of Sound in Liquids changed by Magnetic Field].—Rao : Sibaiya. (*See* 3163.)

3078. On the Differential Equations of Wave Propagation in Gases.—K. Bechert. (*Ann. der Physik*, 4th May 1941, Vol. 39, No. 5, pp. 357–372.) For previous work *see* 2361 of September.

3079. Ultrasonics [with Particular Attention to Metallurgical Applications : including References to Recent Publications].—(*Metallurgist* [Supp. to *Engineer*], 29th Aug. 1941, p. 25.)

PHOTOTELEGRAPHY AND TELEVISION

3080. Theoretical Considerations on a New Method of Large-Screen Television Projection.—F. Fischer & H. Thiemann. (*Schweizer Arch. f. angew. Wiss. u. Tech.*, Jan. & Feb. 1941, Vol. 7, Nos. 1 & 2, pp. 1–11 & 35–45 : Corrections, March issue, No. 3, p. 92 : in German.)

Although momentary brightnesses about ten times as intense as the surface brightness of the best Beck arc lamp have been obtained with fluorescent screens, television projectors using such screens give a picture brightness at least two orders of magnitude less than that given by an ordinary cinema projector. This is due to the short time that the maximum brightness lasts, and can only be overcome by some method of storage. The intermediate-film method is the fundamentally perfect way of storing, but has had to be abandoned because of its expense in working—more than 2500 francs per hour. The supersonic-wave method cannot store over a whole picture (250 000 elements) but only over a line, and its luminous output is thus limited. Fundamentally, the method based on the formation of colour centres in alkali-halide crystals can store over a whole picture-period, but the difficulty is to obtain sufficient opaqueness combined with sufficient mobility. The system using a bank of lamps does solve the problem in a way, but an expensive way. The leaf-electrometer system seems never to have been developed, and the electrographic method has the difficulties of the insufficient opaqueness and the coarseness of the powder layer.

The present paper deals with the new method developed in the Zürich Institute for Technical Physics. In principle, the fluorescent screen of a cathode-ray tube is replaced by a deformable transparent semiconducting medium spread over a flat surface. The scanning ray produces a surface charge varying from point to point, and the resulting electrostatic forces produce deformations of the surface which influence the passage of a beam of light in a way similar to that in the Toepler "Schlieren" process. This beam is focused by the objective O_1 (Fig. 1), before it reaches the deformable surface, so as to form (after it has passed the latter) the image of a system of parallel slits (S) on a system of parallel bars B, so arranged that when the deformable surface is undisturbed no light reaches the projection screen. When, however, the surface is deformed, refraction allows the light to pass by the bars and to be focused by the objective O_2 onto the screen. The ray scanning the deformable surface is modulated in intensity not, as usual, by the image signal itself but by a 7 Mc/s wave modulated by this signal, with carrier suppression, so that "its intensity or 'dwelling time' fluctuates at 7 Mc/s, the amplitude of the fluctuations corresponding to the image signals", thus producing a periodic surface charge whose magnitude at any point corresponds to the brightness of the subject. The resulting deformations of the surface resemble to some extent small lenses, and the amount of deformation controls the amount of light which gets past the parallel-bar system. The conductivity of the semiconducting medium can be so chosen that the leakage of the charge brings about the return to a plane surface in just the time taken for the transmission of a complete frame.

To obtain a linear relation between the deformations and the ray modulation, and also to attain, in the short time available, sufficiently large electrostatic charges, an auxiliary electron-gun is provided to generate a constant polarising potential, uniform over the whole surface ("Vorstromrohr" in Figs. 2 & 4): this uniformity is obtained, in spite of the local potential fluctuations near the surface, by making the auxiliary electrons of sufficiently high velocity. The wiping out of the required local charges by secondary electrons is prevented by the introduction, close to the surface of the medium, of a grid: to avoid the disturbing effect of the formation, on the screen, of the image of this grid, it must move in synchrony with the scanning motion of the ray. The deformable medium, which takes the form of a thin (but not too thin) layer of a viscous liquid, must be provided with a cooling device: this is arranged for by making the shallow circular container revolve slowly and uniformly (Fig. 5) so that a fixed liquid-cooled semicircular plate takes away the heat generated and also, by a skimming-edge, renews the surface. The whole problem is dealt with in detail on the theoretical side, as the title indicates: no experimental results are given.

3081. RCA-NBC Television presents a Political Convention as First Long-Distance Pick-Up [Republican National Convention, Philadelphia, June 1940].—O. B. Hanson. (*R.C.A. Review*, Jan. 1941, Vol. 5, No. 3, pp. 267–282B.) Viewed by about 40 000 people on some 4000 receivers around New York.

3082. Projection of Moving Images on Vaulted Screens.—U. Graf. (*Sci. Abstracts*, Sec. A, July 1941, Vol. 44, No. 523, p. 190.)

3083. Television Film Transmitters using Apertured Scanning Discs [Survey leading to Description of New Form of Scanner using Optical System with Intermittent Magnification ("I.M." System), and Complete Transmitter on This System].—D. C. Espley & D. O. Walter. (*Journ. I.E.E.*, June 1941, Vol. 88, Part III, No. 2, pp. 145–171.)

3084. Television Broadcasting along Lines [Berlin Experimental Network for 441-Line Pictures].—F. Ring. (*T.F.T.*, June 1940, Vol. 29, No. 6, pp. 172–178.

The construction of this network has already been described by Lipfert (2319 of 1940). The present paper deals briefly with noise levels, line compensation, and ranges; transmission standards (including single-sideband); the actual network; and further development possibilities, including the question of the use of the same receiver for wire and wireless television.

3085. Some Thoughts on Television Pick-Up Technique.—G. Goebel. (*T.F.T.*, April 1940, Vol. 29, No. 4, pp. 117–122.) Concluded from 3483 of 1940.

3086. The Design of Television Receiving Apparatus [Electrical, Mechanical, & Psychological Considerations: Mutual Interaction of C-R-Tube & Receiver Design: Time-Base Scanning Generators: Vision & Sound Channels; Power Supply & Mechanical Design: Future Trends].—B. J. Edwards. (*Journ. I.E.E.*, Sept. 1941, Vol. 88, Part III, No. 3, pp. 191–212.) From the Pye laboratories. *See* also 3030, above.

3087. Video Output Systems [Advantages & Disadvantages of Direct Coupling, Grid-, & Diode-Rectification as means for D.C. Reinsertion: Restoration of Low Frequencies by D.C. Reinsertion: Comparison of Shunt-Peaking, Series-Peaking, & Other Methods of obtaining Uniform H.F. Response: Performance of Various Output Valves: etc.].—D. E. Foster & J. A. Rankin. (*R.C.A. Review*, April 1941, Vol. 5, No. 4, pp. 409–438.)

3088. A Vestigial Side-Band Filter for Use with a Television Transmitter [including Appendices on Energy-Distribution in Side-Bands and on Input Impedances of "Type A" & "Type B" Filters].—G. H. Brown. (*R.C.A. Review*, Jan. 1941, Vol. 5, No. 3, pp. 301–326.)

3089. Impedance Irregularities in Coaxial Cables, *and* Recent Developments in Coaxial Cable [Economy in Copper by Introduction of Aluminium].—Aleith & Müller: Keutner. (*Europ. Fernspr: Dienst*, Nov. 1940, No. 56, pp. 175–181: pp. 181–186.) For Keutner's paper on the use of Styroflex *see* 391 of February.

3090. Optimum Design of Physical Apparatus [Mathematical Theory illustrated by Examples from Statistics, Television, etc.].—Spencer. (*Phys. Review*, 15th July 1941, Vol. 60, No. 2, p. 172: summary only.)

3091. CONTRIBUTIONS TO THE THEORY OF THE ELECTRICAL DEFLECTION OF CATHODE-RAY BEAMS: PARTS I, II, and III.—J. Picht & J. Himpan. (*Ann. der Physik*, 31st May 1941, Vol. 39, No. 6/7, pp. 409–501.)

The writers explain the greater popularity of the magnetic system of deflection (but *cf.* 3123, below) in television as the result of the intensive development which has gone on in the laboratory, where it has certain advantages in simple and rapid construction and mounting. In the end, however, they consider that the special merits of electrostatic deflection will come into their own: such a system consumes less power, uses up less material, and yields smaller time constants—an important point in the further development of television, as well as for oscillographs for extremely rapid oscillations. The theory of electrostatic and magnetic focusing has already reached a high state of development, but that of deflection has been neglected except by Wendt (magnetic deflection: 3225 of 1939) and Glaser (electric-magnetic: 2204 of August and back reference). The present papers therefore give a thorough theoretical treatment of electrostatic deflection systems, free from the limitation on the magnitude of the deflection which is assumed by both the above writers.

Authors' summary of Part III:—"We first discuss the ideal dynamic picture formation by means of two electrically charged deflecting systems of variable potential with their deflecting directions crossed at right angles. Then, in section 2, the results of Part II are employed to derive the image errors due to the first deflecting prism. It is shown that here no errors of the first and second order occur, only those of the third order. Further, the errors produced by the second deflecting system are derived, and the influence of the first system on these, and conversely the influence of the second system on the errors due to the first, are discussed. Finally, the resulting expressions for the errors are examined more closely and the effect of the resulting errors on the quality of the image are discussed and illustrated by a series of graphical representations, the magnitude relations between the coefficients representing the individual errors, and in certain cases their necessary signs, being considered."

3092. ELECTRON-CURRENT AMPLIFICATION IN PHOTOCELLS, BY COMPENSATION OF THE SPACE CHARGE AT THE INCANDESCENT CATHODE [by Positive Ions].—L. Goncharski. (*Journ. Tech. Phys.* [in Russian], No. 3, Vol. 10, 1940, pp. 237–242.)

Experiments were carried out with gas-filled photocells (Fig. 1) consisting essentially of a semi-cylindrical photocathode 1, a coaxial cylindrical (meshed) anode 2, and an incandescent cathode 3 mounted along the axis of the cylinder. The composition of the gas, the gas pressure, the potential difference between the electrodes, and the intensity of illumination were varied and their effect on the amplification factor was investigated. Frequency characteristics of the cells were taken and experiments were also conducted with multi-stage cells (Fig. 11). The following main conclusions were reached: (1) Using compensation of the space charge, single photocells with an amplification factor of 10^5 can be obtained without any considerable increase in the supply voltage; (2) multi-stage photocells with an amplification factor of 10^9 can be obtained with a supply voltage of 500–600 v; and (3) an electro-magnetic relay can be connected to a multi-stage cell; a sensitive photo-relay can thus be obtained.

3093. PHOTOELECTRIC CELLS FOR THE VISIBLE SPECTRAL RANGE [" Alloy " Cathodes (Sb-Cs, Sb-Li, Bi-Cs, etc.) with " Surprisingly High " Sensitivities].—P. Görlich. (*Journ. Opt. Soc. Am.*, July 1941, Vol. 31, No. 7, pp. 504–505.) *See* also 1703 of June (particularly the last paragraph) and back reference.

3094. CONTRIBUTION TO THE QUESTION OF THE SECONDAY EMISSION FROM SUBLIMATED ALKALINE-EARTH FILMS.—Görlich. (*See* 3054.)

3095. ON THE MECHANISM OF SECONDARY EMISSION OF ELECTRONS FROM COMPOSITE SURFACES [of Caesium-Oxygen Type].—P. V. Timofeev. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 10, 1940, pp. 3–6.) This is the same paper as that covered by 3495 of 1940.

3096. ON THE NATURE OF THE SECONDARY EMISSION FROM COMPOSITE CATHODES.—N. D. Morgulis. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 10, 1940, pp. 79–80.) A letter by Morgulis in reply to criticisms of his paper (1504 of 1940) put forward in Timofeev's paper (3095, above).

3097. THE SECONDARY-ELECTRON EMISSION FROM OXYGEN-CAESIUM EMITTERS AT LOW VELOCITIES OF PRIMARY ELECTRONS.—P. V. Timofeev & K. A. Yumatov. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 10, 1940, pp. 8–11.)

An experimental investigation has led to the following conclusions:—(1) When the velocity of the primary electrons is varied from 0 to 50 v the secondary-emission coefficient σ is approximately equal to unity up to a certain velocity, beyond which it increases linearly (Fig. 2). The actual value of the critical velocity depends on the number of caesium atoms in the upper layers of the emitter. (2) The maximum value of σ for a velocity of 50 v is obtained when the Ag_2O layer is 140 to 200 molecular layers thick. A theoretical interpretation of the above conclusions is given (*see* 3495 of 1940).

3098. THE ELECTRON EMISSION FROM OXYGEN-CAESIUM CATHODES WITH GOLD PARTICLES IN THE INTERMEDIATE LAYER.—P. V. Timofeev & Yu. I. Lunkova. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 10, 1940, pp. 12–19.)

On the basis of investigations by de Boer (1932 Abstracts, p. 355) and others it appears that the fatigue of oxygen-caesium photocathodes may be reduced if the conductivity of the intermediate layer is increased. A number of investigators have experimented with cathodes on whose surface gold particles and particles of other metals were deposited, but it is pointed out in the present paper that with the surface-deposition of metal particles it is impossible to obtain a uniform distribution of these in the intermediate layer. Accordingly, methods are described for producing such cathodes, and results are given of an experimental investigation which shows that cathodes free from fatigue can thus be obtained. An improvement in the conductivity of the intermediate layer was also achieved by preparing the cathodes on a rough silver surface. The properties of the above cathodes have been thoroughly investigated and a number of experimental curves are shown. The results obtained line up with the general conception of Timofeev on the rôle of positive charges formed on the surface of emitters during electron emission (*see* 3495 of 1940).

3099. Antimony-Caesium Emitters.—P. V. Timofeev & Yu. I. Lunkova. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 10, 1940, pp. 20–23.)

The photoelectric properties of antimony-caesium emitters were investigated experimentally, and it was shown that under strong illumination the photocurrent becomes independent of the intensity of the light falling on the emitter surface (Fig. 2). The relationship between the secondary-emission coefficient σ and the thickness of the antimony-caesium layer was also investigated.

3100. The Secondary Emission from Sulphur-Caesium Emitters.—P. V. Timofeev & K. A. Yumatov. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 10, 1940, pp. 24–27.)

An experimental investigation which shows that the secondary-emission coefficient σ of sulphur-caesium emitters is somewhat higher than that of oxygen-caesium emitters. The maximum value of σ was obtained with a layer of Ag_2S having a thickness of 60 to 80 molecules (Fig. 3).

3101. Secondary Emission from the Oxides of Metals.—P. V. Timofeev & A. V. Afanaseva. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 10, 1940, pp. 28–31.)

Experiments were carried out with oxides of silver, nickel, molybdenum, and magnesium to which particles of pure metals were added. The main conclusion reached is that the properties of the oxides are more important than the nature of the metallic particles.

3102. Oxygen-Barium and Oxygen-Caesium Secondary-Electron Emitters.—P. V. Timofeev & P. M. Aranovich. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 10, 1940, pp. 32–38.)

Manufacturing conditions are established for producing oxygen-barium and oxygen-caesium emitters with the highest coefficient of secondary emission σ. The effect on σ of the temperature at which the emitter is operated, and of the primary-current density, is also investigated.

3103. The Secondary-Electron Emission from Oxygen-Caesium Emitters at Different Primary-Current Densities.—P. V. Timofeev & A. I. Pyatnitski. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 10, 1940, pp. 39–46.)

In papers hitherto published on the subject, measurements are given of secondary-electron emission from oxygen-caesium emitters for a primary-current density not exceeding 10^{-8}–10^{-7} A/cm. In the present paper an account is given of experiments in which the relationship between the secondary-emission coefficient σ and the primary-current densities up to 10^{-4} A/cm was investigated. The effect on σ of a prolonged continuous action of the electron beam on the surface of the emitter was also studied.

3104. Photocells with Multi-Stage Amplification of Photocurrent using Secondary-Electron Emission.—P. V. Timofeev. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 10, 1940, pp. 47–62.)

Various methods for multi-stage current amplification by secondary-electron emission are considered, and a description is given of cells developed by the author. Attention is mainly given to a cell in which the direction of the flow of secondary electrons is controlled by grids mounted in front of the emitters. Each of these grids is connected to the following emitter (Fig. 2c). A theoretical investigation, verified experimentally, of these cells is presented, and the following points are discussed in particular :—the properties of the cells when operated with constant and alternating voltages (*see* also 4369 of 1940) ; the effect of the size, number, and disposition of electrodes on the amplification factor ; the threshold of sensitivity ; and noises generated in the cell. On the basis of this investigation, low-voltage cells operating with 750 V and having a sensitivity of the order of 1 A/lumen have been constructed.

3105. The Flow of Electrons between Two Non-Parallel Flat Electrodes.—P. V. Timofeev & E. G. Kormakova. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 10, 1940, pp. 63–65.)

In electron amplifiers with flat s.e. emitters and a grid between them which serves to control the direction of the flow of electrons (Fig. 2), the coefficient of dispersion of the electrons can be reduced to below 1% by suitably choosing the angles of the inclination of the emitters towards the grid. These angles can be determined from formula (1).

3106. Secondary Electrons from Semiconductors with Marked Photoelectric Properties [especially Selenium].—Wolff. (*See* 3056.)

3107. A New Technique for preparing Monocrystalline Metal Surfaces for Work Function Study. The Work Function of Ag(100).—P. A. Anderson. (*Phys. Review*, 15th June 1941, Vol. 59, No. 12, pp. 1034–1041.) *Cf.* 2173 of August.

MEASUREMENTS AND STANDARDS

3108. The Measurement of Interference at Ultra-High Frequencies [and Design & Performance of Measuring Set, on Principles deduced, usable both for Field-Strength & Voltage Measurements].—Daniel & Mole. (*See* 3028.)

3109. Theory and Experimental Confirmation of Calibration of Field-Strength Measuring Sets by Radiation [" Standard Field " Method], *and* A Method of Calibrating a Field-Strength Measuring

Set [Laboratory (Current & Resistance) Method].—J. S. McPetrie & J. A. Saxton: F. M. Colebrook & A. C. Gordon-Smith. (*Journ. I.E.E.*, March 1941, Vol. 88, Part III, No. 1, pp. 11–14: pp. 15–17.)

The close agreement between the results of the two methods at 8 m and 20 m shows that either method can be used in this band: it is concluded that the radiation method using horizontally polarised waves would be unsatisfactory for waves much above 30 m.

3110. The Application and Use of Quartz Crystals in Telecommunications.—Booth. (*See* 3018.)

3111. Physics and Technique of Piezoelectric Phenomena. — E. Hameister. (*T.F.T.*, April & May 1940, Vol. 29, Nos. 4 & 5, pp. 122–125 & 151–157.)

Author's summary:—" Starting from the theory of the elastic properties of crystals, and with the help of the potential concept in its elastic and electrical aspects, the phenomena of piezoelectricity are considered. For the physical explanation the Debye molecular theory is invoked, showing the connection of piezoelectricity with ferromagnetism; since (for example) the dielectric displacement current corresponds to magnetic induction, and the electric field-strength to the magnetic field-strength. For quartz, the various constants which determine the electrical values are given in greater detail. Further, the measuring methods for the effect are mentioned, the equivalent circuit for such crystals is derived, and some important cases in h.f. technique (filter, transmitter) are described ".

3112. The Properties of Quartz Oscillators & Resonators at Audio & Medium Frequencies.—L. Rohde & H. Handrek. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 21, 1940, pp. 401–405.)

" By the use of special electrodes and fixing methods, as was shown in previous papers [2456 of 1939 and 2360 of 1940] it has become possible to extend the use of quartzes to the frequency range from 50 kc/s down to 1000 c/s. For such frequencies it is chiefly a question of flexural vibrators, the longitudinal type being impracticable. Since these quartz vibrators are now being widely used, their properties and applications will be described here."

The four sizes of holder covering the whole range mentioned are illustrated. They cause about 70% of the damping. There is no need to use a vacuum, since the damping effect of the air is very small for small amplitudes, and for larger amplitudes is often very useful in protecting the quartz against overloading. The absolute amount of air damping increases with increasing frequency. The pure natural damping of the quartz bar could not be measured: it should be about 10^{-5}. The " three-pole " bar is the most useful: the " two-pole " type has an inconveniently large parallel capacity and the use of the " five-pole " type hardly ever adds to the possible applications. The paper deals therefore exclusively with the " three-pole " type, and table 1 gives the values for the elements of its equivalent circuit (Fig. 5) for various frequencies up to 60 kc/s. The damping δ is seen to be between 0.00019 and 0.00056—much less than that of the best tuning fork.

Fig. 7 gives the equivalent circuit for the use of a " three-pole " quartz as a filter, with a pure ohmic load and with capacitive and ohmic-capacitive loads. The three main equations on p. 403 give the ratio between the output and input voltages in each case (the left-hand term in the first equation is printed upside-down), showing how the transmission through the filter depends on the frequency. Below each equation, the simplified form it takes at resonance is given: for the ohmic load the voltage ratio depends only on the ratio of the internal resistance to the load resistance, in the other cases capacitive and damping terms are involved. Since the input voltage must be limited to about 10 v, the above relations allow the max. transmissible watts to be determined. Examination of the formulae shows that the loading of the filter produces not only a change in amplitude but also (with a capacitive load) a slight detuning whose amount depends on the ratio of the output capacitance C_{20} (equivalent circuit of Fig. 5) to the internal capacitance C_q. For values of 20 pF and 0.002 pF respectively, the frequency change comes out at under 10^{-5} per picofarad.

Since the capacitance C_{12} across the filter is naturally not the ideal zero but a finite quantity whose value can be taken from table 1, parallel resonance is possible in addition to series resonance. Fig. 8 shows the percentage spacing between the two resonance points as a function of the ratio of the internal quartz capacitance C_q to the parallel capacitance C_{12} (here called C_p): the spacing becomes greater as this ratio is increased; for practical values of the ratio the percentage spacing is considerable, and the parallel resonance gives no trouble.

Fig. 9 shows how the " three-pole " quartz can be connected as a filter, either as an input stage before a valve or as a coupling stage between two valves. The sharpness of resonance is so acute that an attenuation of 10^4 can be produced by a detuning of a fraction of 1%. Since the internal resistances and capacitances of different quartzes do not vary very greatly, it is possible to connect several in parallel, and a filter passing from 6 to 8 different frequencies is easily obtainable, with a 10^4 attenuation for detunings exceeding 0.5%. Two filters in series through a valve will give a practical suppression up to 10^7—" values which are attainable only with these quartzes," which have moreover the advantages of great simplicity and require only electrostatic screening, since magnetic couplings cannot occur.

Fig. 10 shows the very simple generating circuit made possible by the phase-reversing property of the " three-pole " quartz: the circuit components are chiefly ohmic resistances, so that the frequency is determined only by the quartz. The influence of the circuit-component values has been examined already (2360 of 1940): in practice it has been found advantageous to provide automatic voltage limitation by an auxiliary rectifier (*D* in Fig. 10), which derives from the anode a.c. a grid bias limiting the a.c. grid potentials to just the value necessary for controlling the valve. In this way the optimum conditions for the building-up and stable régimes can be obtained by a suitable choice of component values. Either sinusoidal or square-wave forms can be arranged for, or a sinusoidal and a distorted form can be derived simultaneously, one from the grid and the other from the anode. By adding, to a 1 kc/s oscillator, a quartz filter for 50 kc/s, the 50th harmonic can be obtained from the oscillator, free from the 49th and 51st harmonic—a result which with ordinary filters would require a large outlay in apparatus.

Table 2 shows the temperature coefficients of frequency for various flexural quartzes: they range between about -5 and -11×10^{-6}/deg. C. The larger values previously given (*loc. cit.*) were due to an imperfect design of holder. With a constant temperature a very high frequency constancy is attained, but there is a certain small increase in frequency, after the quartz has first been put into service, which must be classified as an ageing effect in the quartz, its electrodes, and its holder. The frequency rises most quickly at first and then tends towards a final value which is practically constant—after about a month in the case of the 1000 c/s quartz whose ageing effect is seen in Fig. 11: it is stated here that after 100 days the daily increase is less than 3×10^{-8}, whereas in the first ten days the total increase taken from the curves was about 1.3×10^{-6}. It seems from the short pieces of curve, representing the behaviour of an oscillator which was frequently switched on and off, that the ageing effect still tends to the same final value, so that even a generator treated in this way will be constant after a time. A 1000 c/s quartz showed a marked increase during the first month, but during the next 9 months the total change was less than one millionth.

3113. On the Performance of Two Commercial Quartz Clocks [at the German Naval Observatory].—H. Dobberstein. (*Zeitschr. f. Instr:kunde*, June 1941, Vol. 61, No. 6, pp. 188–191.) Results of a year's experience with clocks of the design described by Rohde & Leonhardt, 1956 of July.

3114. The Theory of the Synchronisation of Relaxation Auto-Oscillations.—Kholodenko. (*See* 3009.)

3115. Errors of Observation due to Instrument-Scale Limitations.—Golde. (*See* 2995.)

3116. Rectification Conditions and Scale Shape: a Contribution to the Question of Range Extension in Rectifier-Type Meters.—H. F. Grave. (*Arch. f. Elektrot.*, 15th April 1941, Vol. 35, No. 4, pp. 245–257.)

3117. A Precision Thermionic A.C. Test Set [Combined Voltmeter, Ammeter, & Wattmeter for Range 50–1000 c/s, suitable for dealing with Distorted Wave-Forms: with Specially Stabilised Amplifier between Load & Pressure Coil].—K. A. Macfadyen & N. D. Hill. (*G.E.C. Journal*, Feb. 1941, Vol. 11, No. 3, pp. 182–187.)

3118. New Valve Voltmeters [including a General Laboratory Model for Frequencies from 20 c/s to 200 Mc/s].—Salford Elec. Instruments. (*Electrician*, 22nd Aug. 1941, Vol. 127, p. 108.)

3119. An Integrator for Small Currents [from 0.05 μA to 30 μA: Neon Tube, Amplifier, & Mechanical Counter Combination].—B. E. Watt. (*Review Scient. Instr.*, July 1941, Vol. 12, No. 7, pp. 362–365.) The upper limit could be extended to 200 μA, or (by replacing the neon bulb by a voltage-regulator tube) to still higher values. The circuit is independent of power-supply fluctuations.

3120. Superconducting Films as Radiometric Receivers.—Andrews & others. (*See* 3204.)

SUBSIDIARY APPARATUS AND MATERIALS

3121. Contributions to the Theory of the Electrical Deflection of Cathode-Ray Beams.—Picht & Himpan. (*See* 3091.)

3122. Deflection and Impedance of Electron Beams at [Ultra-] High Frequencies in the Presence of a Magnetic Field.—Malter. (*See* 3044.)

3123. Electroballistic Measuring Method for the Construction of Electron Paths in a Rotationally Symmetrical Magnetic Field: I—Theoretical Foundations.—Sándor. (*Arch. f. Elektrot.*, 15th April 1941, Vol. 35, No. 4, pp. 217–228.)

In spite of the work of Störmer and of Knoll & Ruska, there is still lacking a universal method by which the carrier paths can be determined continuously, in any form of magnetic lens field, so that the quantities important in electron optics—the position of the focus and the principal planes, and the exact focal length—may be derived, and the aberrations estimated. "This is clearly the reason why the systematic development of electrostatic lenses has forged ahead of that of magnetic lenses [but *cf.* 3091, above], although in many practical cases the latter have more favourable electron-optical and practical qualities than the electrostatic type." The chief trouble is the three-dimensional path-curve of the magnetic lens, which requires three equations of motion for its representation: if, in addition, an electrical field also acts on the ray, purely mathematical methods become in most cases quite hopeless.

Dosse's work (4057 of 1936) adapted Störmer's astrophysical treatment to the magnetic lens, by relating the spatial-field problem to a plane-field, electrical one, thus making possible the graphical determination of the carrier paths with the help of the electron-optical refraction law (Knoll's paper, 439 of 1935, is here referred to). He also pointed out the possibility of determining, by superposition, the course of the path in the simultaneous presence of an electric field coaxial with the magnetic. The method, however, demanded that the magnetic field function of the induction flux of the lens should be determined empirically, except in certain simple cases where the necessary values could be calculated. "It is the purpose of the present work to devise a practical measuring method to obtain the values necessary for path determination by the above method, and to demonstrate the practical applicability of the whole process. It is based on the idea of projecting the generally spatial path onto a plane rotating with the electron about the optical axis, thus converting the spatial path problem to a planar one. Because of the equivalence of mechanical and electrical energy, the rotational velocities of the carrier in the rotating plane can be replaced by electrical potentials, in such a way that their combined effects provide the so-called 'auxiliary potential field' which behaves, as regards the carrier-path construction, like an ordinary electrostatic field. The path construction then follows very simply with the help of the electron-optical refraction law, which gives an approximate curve made up of straight-line elements." Part II will describe a complete measuring apparatus for determining the magnetic field function necessary for the above process.

3124. Electrical Bombardment of Biological Materials: II—An Electron Tube for the Production of Homogeneous Beams of Cathode Rays from Ten to One Hundred Kilovolts [with Intensities $10^{-6} - 10^{-10}$ Coulomb per Square Centimetre: Electron Gun, Three-Stage Accelerator, Collimating Slit, & Raying Chamber].—Morningstar, Evans, & Haskins. (*Review Scient. Instr.*, July 1941, Vol. 12, No. 7, pp. 358–362.)

3125. An Electron-Lens Type of Beta-Ray Spectrometer [using 66″ Solenoid producing (with 600 A) a Field of 1115 Oersteds with Homogeneity better than 1%].—Witcher. (*Phys. Review*, 1st July 1941, Vol. 60, No. 1, pp. 32–42.) For Deutsch's use of a flat-coil lens *see* 2203 of August.

3126. "The Cathode-Ray Oscilloscope: Second Edition" [for Service Engineers, Service Training Schools, etc: Book Notice].—Miller. (*Wireless World*, Sept. 1941, Vol. 47, No. 9, p. 230.)

3127. A Two-Stage Electron Microscope.—Houston & Bradner. (*Phys. Review*, 15th Jan. 1941, Vol. 59, No. 2, p. 219: summary only.) Referred to in 1171 of April: from the California Institute of Technology. For another two-stage type *see* 2812 of October.

3128. The Determination of the Resolving Power of Electron Microscopes [Special Technique for Preparation of Test Wedges: Resolving Power of Universal Microscope (2709 of 1940) found to be 2.2 mμ].—von Ardenne. (*Physik. Zeitschr.*, March 1941, Vol. 42, No. 4/5, pp. 72–74.)

3129. Stable Power Supplies for Electron Microscopes [with Electronic Regulators for 20–100 kV & Other Supplies].—Vance. (*R.C.A. Review*, Jan. 1941, Vol. 5, No. 3, pp. 293–300.)

3130. The Acceleration of Electrons by Magnetic Induction [Energy of 2.3 MeV obtained by Electric Field accompanying a Changing Magnetic Field: Inward Spiralling towards Tungsten Target, producing Pronounced Beam of X-Rays], *and* Electronic Orbits in the Induction Accelerator.—Kerst: Kerst & Serber. (*Phys. Review*, 1st July 1941, Vol. 60, No. 1, pp. 47–53: *See* also 2219 of August.

3131. A New Calculus for the Treatment of Optical Systems.—Clark Jones, Hurwitz. (*See* 2992.)

3132. Koroseal Synthetic now Obtainable in Mono-Strands [primarily for Apparel Uses].—(*Review Scient. Instr.*, July 1941, Vol. 12, No. 7, p. 379.) For the use of Koroseal in vacuum technique *see*, for example, 2505 of 1939.

3133. Insulated Vacuum Leads [with Moulded-Glass Insulators: primarily for Replaceable Filament Assembly in All-Metal Gaseous Magnetron].—Bleil & Hause. (*Review Scient. Instr.*, July 1941, Vol. 12, No. 7, pp. 369–370.)

3134. On the Production of High Vacua [Survey].—Musco. (*La Ricerca Scient.*, Dec. 1940, Vol. 11, No. 12, pp. 985–1000.)

3135. The Theory of the Synchronisation of Relaxation Auto-Oscillations.—Kholodenko. (*See* 3009.)

3136. A New Circuit for generating Alternating Electric Pulses of Very Short Duration.—Potapenko. (*See* 3024.)

3137. Studies of a Ring Discharge [in Mercury Vapour].—Smith. (*See* 2966.)

3138. Transient Processes in D.C./A.C. Inverters: Corrections.—Müller-Strobel. (*Arch. f. Elektrot.*, 15th April 1941, Vol. 35, No. 4, p. 258.) *See* 2380 of September.

3139. Extra-Heavy-Duty Resistors [Type MTG, Plug-In, with Fibre-Glass Insulation: handles 3 Times the Power of Usual Bare Winding in Radio Sets].—Clarostat. (*Review Scient. Instr.*, July 1941, Vol. 12, No. 7, p. 372.)

3140. Electrical Conduction and Crystallisation Phenomena in Thin Films deposited at Low Temperatures.—Armi. (*Phys. Review*, 15th July 1941, Vol. 60, No. 2, p. 162: summary only). Further development of Foster's work on lead films with resistances up to 10^{15} ohms (1624 of 1940).

3141. Dielectric Loss in Thin Films of Insulating Liquids [Theory (& Experimental Confirmation) based on Ionic Motion limited by Boundaries of Film: Application to Impregnated Dielectrics: Effects of Impurities: etc.].—C. G. Garton. (*Journ. I.E.E.*, March 1941, Vol. 88, Part III, No. 1, pp. 23–40.)

Abridgment of E.R.A. Report L/T 108. "The experiments suggest that if a means, such as extremely small pore-size, could be devised to restrict sufficiently the ionic motion, it would be possible to utilise liquids of higher dielectric constant than is now practicable for condenser impregnation."

3142. On the A.C. Resistance of Porous Ceramic Materials containing Argillaceous (and sometimes also Magnesium-Silicate) Components, Groups IVB and V of the DIN 40685 Table, at Temperatures up to 600° C.—Richter. (*Physik. Zeitschr.*, 15th June 1941, Vol. 42, No. 7/8, pp. 117–120.)

It has been shown that the use of d.c. potentials in the measurement of the insulating resistance of ceramic materials at high temperatures may produce secondary processes which will influence the results (2069 of 1938): a method of measurement was therefore developed for obtaining reproducible specific a.c. resistance values (825 of 1940), by which some data for the dielectric properties were obtained (4453 of 1940). This method was adopted by the VDE and is directly applicable to the dense ceramic materials in groups I—IVA of their table, but for the argillaceous materials resisting high temperatures, in groups IVB and V, the porous nature of the material requires special methods in the application of the electrodes. A separate investigation is therefore necessary for these materials (such as Sipa 14, Sipalox, Steatite G and Q5) and this is dealt with in the present paper, the results being compared with those of the previous groups (Calit, Ardostan, etc.).

3143. Discussion on "Ceramic Insulations for High-Frequency Work."—Robinson. (*Journ. I.E.E.*, June 1941, Vol. 88, Part III, No. 2, pp. 172–174.) *See* 872 of March.

3144. On Surface-Leakage Paths and Resistance to Surface-Leakage Current [in Organic Insulating Materials].—Stäger & Siegfried. (*Schweizer Arch. f. angew. Wiss. u. Tech.*, April 1941, Vol. 7, No. 4, pp. 93–109.)

Beginning with a short review of recent researches, the paper then gives a description of the writers' electrical measurements and microscopic investigations on wafers of various phenol-formaldehyde, cresol-formaldehyde, and aniline-formaldehyde condensation products. "The tests have shown, as has already been established, that in these materials a structure can be found in which certain components are non-uniformly distributed. The electrolyte moves in the border surfaces, from where start paths of surface leakage. It is found that the nature of formation of the leakage path depends on the electrolyte and structure relations. The moisture of the air plays a predominant rôle here: at low moisture values no leakage paths appear. On the results of these investigations the formation of leakage paths is classed as a corrosion phenomenon, and the strength against surface-leakage current is correspondingly compared to the resistance to corrosion." For the first chapter of a paper by the same writers with Sänger, on "Investigations on Phenoplastics," see *ibid*, May 1941, No. 5, pp. 129–139.

3145. Anomalous Dispersion and Dielectric Loss in Polar Polymers [Theory of Dielectric Loss at High Dilution in Non-Polar Plasticiser: Approximate Relation between Degree of Polymerisation, Frequency of Max. Loss, & Viscosity Coefficient of Polar Plastic: etc.].—Kirkwood & Fuoss. (*Sci. Abstracts*, Sec. A, July 1941, Vol. 44, No. 523, p. 189.) *See* also 2841 of October.

3146. Thread Production, Thread Properties, and Molecular Structure: Molecular Physical Considerations on the Spinning Process.—Müller. (*Physik. Zeitschr.*, 15th June 1941, Vol. 42, No. 7/8, pp. 123–129.)

Of interest in connection with the treatment of Polystyrol, etc. (*see* 2840 of October).

3147. The Development of Thermal Breakdown with Time.—Grünberg, Kontorovich, & Lebedev. (*Journ. of Tech. Phys.* [in Russian], No. 3, Vol. 10, 1940, pp. 199–216.)

A mathematical theory is developed for calculating, with sufficient accuracy for practical purposes, the time necessary for a dielectric to break down by thermal action when a voltage is applied exceeding the critical value at which stability of the dielectric becomes impossible and a continuous warming-up process begins.

3148. The Extraction of Electrons from Cold Metals at High Field Strengths [Survey].—Willis Jackson & Chester. (*Journ. I.E.E.*, April 1941, Vol. 88, Part I, No. 4, pp. 149–160.)

"It is concluded that the Fowler-Nordheim theory is substantially correct in giving the dependence of field currents on the field strength and temperature, and also in respect of the energy distribution of the electrons involved. The extension of this relation to include the effect of electropositive surface films appears to be justified experimentally, though there is need for further quantitative confirmation. The significance of field emission in relation to breakdown phenomena, the mercury arc, and materials of non-linear electrical characteristics is discussed . . ."

3149. Electrical Insulating Materials [Review of Progress].—Haefely. (*Journ. I.E.E.*, May 1941, Vol. 88, Part I, No. 5, pp. 179–188.)

3150. Correlations in Dielectric Data [Either Real or Imaginary Part of Complex Dielectric Constant is determined if Complete Frequency Dependence of Other is Known: Possible Applications].—Cole. (*Phys. Review*, 15th July 1941, Vol. 60, No. 2, p. 172: summary only.) *See* also 2833/5 of October.

3151. Frequency Characteristic and Equivalent Circuit of the Electrolytic Condenser.—Wachenhusen. (*Hochf: tech. u. Elek: akus.*, May 1941, Vol. 57, No. 5, pp. 125–134.)

From the Siemens & Halske laboratories. The writer's measurements of the capacitance and loss factor of dry electrolytic condensers over the range from 1 c/s to 20 Mc/s show that the theories and equivalent circuits evolved by various workers (*see* for example Söchting, 1503 of May: von Kilinski, 746 of 1940) cannot explain the frequency characteristics of such condensers over so wide a range. He therefore sets himself to derive, from his results, a complete and generally valid equivalent circuit.

Unlike the writers mentioned, he discards, in his experimental work, the measuring method in which an a.c. voltage is superposed on a direct voltage. He finds it fundamentally possible to measure any electrolytic condenser by pure a.c. voltages, provided that these do not exceed in amplitude a definite small value, actually in these experiments below 0.5 volt. Errors due to unwanted additional "forming" action do not then occur, and it does not matter for what voltage the condenser is designed or whether it is of the "poled" or "unpoled" type. Also, upsetting changes, with time, in capacitance and losses which were encountered, for example, by Söchting, and explained by Herrmann (2826 of October) as due to the switching-on and off of the d.c. voltage, are thus avoided.

The complete equivalent circuit evolved to satisfy his measurements is shown in Fig. 15. It contains rather a large number of elements compared with the circuits hitherto proposed. It takes into account the capacitances and losses of the oxide layer and of the so-called " polarisation " layers at the metal/electrolyte transitions, the resistance and capacitance of the electrolyte film, and the inductances and resistances of the connections. The frequency-dependent elements first employed to represent the oxide layer were later able to be replaced by constant elements as a result of measurements of the frequency dependence. The complete equivalent circuit can be simplified for practical purposes by limiting the frequency range of its validity. Thus the range 20 c/s to 20 Mc/s can be considered as divided into three ranges, (1) the low-frequency range in which only the oxide layer and its properties play a part, (2) in which the resistance and capacitance of the electrolyte layer also become important, and (3) in which the connection inductances are predominant. The influence of the forming voltage and the roughening of the anode is also pointed out.

In the important range (1) the capacitance decreases only slowly (Fig. 5), in correspoudence with the natural-frequency characteristic of the oxide layer. In range (2) it falls much more quickly, reaching in the most unfavourable case the value of the capacitance of the electrolyte layer (C_{AK} in the equivalent circuit). Tan δ in range (1) is approximately constant (Fig. 6); in range (2) it increases steeply to a maximum, drops again, and then rises to a second maximum at the transition from range (2) to range (3), that is, at the resonance frequency. Nowhere in the region below the resonance frequency does it exceed the value 5. Von Kilinski's view that $\tan \delta$ may reach 1131 is based on the wrong assumption that the condenser series capacitance C_r is approximately independent of frequency. The position of the transition frequency between ranges (1) and (2) depends on the ratio of the electrolyte-layer resistance R_{El} to the capacitive resistance $1/\omega C_r$, which is particularly infiuenced by temperature and by roughening of the anode. The usual shape of the condenser frequency characteristic can be changed considerably if the specific resistance of the electrolyte layer is not everywhere the same. Measurements are included of the capacitance at a frequency of 1 c/s: all the condensers tested gave values from 2 to 16% higher than at 50 c/s. Large changes in the circuit time constant made no appreciable change in the measured values, so it is concluded that the d.c. capacitance is not greatly different from that at 1 c/s.

A good deal of space (pp. 132–133) is devoted to a special test and discussion on the comparative importance of the part played by the so-called " polarisation " capacitances mentioned above as included in the complete equivalent circuit (elements *c* and *e* in Fig. 15). The experiment shows the necessity for this inclusion, although in some cases the effect on the frequency characteristic is negligible. These capacitances are liable, moreover, to irreversible changes with time and temperature, particularly in the case of low forming voltages.

3152. METAL-COATING PROCESS FOR PHENOL-FORMALDEHYDE MOULDINGS AND OTHER PRODUCTS [to replace Metal Cases: Very Good Screening Properties, etc.].—Plastic Sprays. (*Electrician*, 22nd Aug. & 12th Sept. 1941, Vol. 127, pp. 107–108 & 152.) *See* also *Engineer*, 22nd Aug. 1941, Vol. 172, p. 125.

3153. CONTRIBUTIONS ON THE SCREENING ACTION OF COVERINGS AGAINST LEAKAGE FIELDS OF 50 c/s ALTERNATING CURRENT.—Schadwinkel. (*Hochf: tech. u. Elek: akus.*, May 1941, Vol. 57, No. 5, p. 138: summary of brochure.)

The action of screens against h.f. fields has been dealt with adequately in the literature, but commercial-frequency fields have been neglected. Such fields, produced by mains transformers or leads, occur so frequently in amplifier technique that a special and thorough investigation is justified (for previous work by the writer *see* 493 of 1939 and back reference). For the mathematical analysis of the problem the open-ended and completely closed screens considered are replaced by equivalent structures, an infinitely long cylinder and a sphere. For the cylinder, the investigation leads to a second-order differential equation whose solution contains Bessel and Neumann functions. By fixing the boundary conditions at the cylinder surfaces, the screening factor is obtained: the complex expression obtained for this shows that a phase displacement in time takes place with respect to the original field. Penetration depth is discussed and from the exact equation a simple formula for this is obtained. Regarding the sphere, as a representation of the completely closed screen, Kaden's work is discussed (*see* Moeller's paper on magnetic screening, 2237 of August): the magnetostatic and electromagnetic actions are distinguished, and it is shown that at 50 c/s the former is predominant: an examination of certain terms neglected by Kaden leads to the conclusion that his methods may lead to serious errors with small screens and thick walls.

The second part of the brochure describes experiments to check the theoretical conclusions, with various materials and dimensions. The effect of an air gap in the screen is examined: a 55% decrease in screening action may thus be produced. Multiple screening is examined, and found always to be better than single screening, for the same outlay in material: the optimum ratio of dimensions is determined. Perhaps the most important part of the work for the practical man is the collection of curves giving the screening action for various materials and dimensions.

3154. " ELECTRIC AND MAGNETIC FIELDS " [including Shielding, Valve Design ,& Tables of Statistical Data: Book Review].—Attwood. (*Journ. Franklin Inst.*, July 1941, Vol. 232, No. 1, p. 95.)

3155. IRON POWDER [for Powder Metallurgy (Moulding & Sintering Process)].—(*Review Scient. Instr.*, July 1941, Vol. 12, No. 7, p. 379.) *Cf.* Amman, 2879 of October.

3156. The Magnetostriction, Young's Modulus, and Damping of 68 Permalloy as Dependent on Magnetisation and Heat Treatment.—Williams & others. (*Phys. Review*, 15th June 1941, Vol. 59, No. 12, pp. 1005–1012.)

STATIONS, DESIGN AND OPERATION

3157. Frequency Modulation [Short Generalised Theory (Frequency & Phase Modulation): Deviation & Band Width: Noise-Reducing Properties: Interference between Carriers: F.M. Methods: Modulation of Phase to produce Frequency Modulation: Direct F.M.: Receiver Considerations: Bibliography].—Seeley. (*R.C.A. Review*, April 1941, Vol. 5, No. 4, pp. 468–480.)

3158. The Use of Frequency Modulation in Broadcasting and Radio Communication in the U.S.A. [Discussion of F.C.C. Meeting of March 1940].—Smirnov. (*Elektrosvyaz* [in Russian], No. 1, 1941, pp. 5–17.) *Cf.*, for example, 2765 of 1940.

3159. Engineering Factors involved in relocating WEAF [when Power was raised from 5 to 50 kW, to serve Greater New York Area: Choice of Site & Moderately Directive Aerial System].—Guy. (*R.C.A. Review*, April 1941, Vol. 5, No. 4, pp. 455–467.) *See* also 921 of March.

3160. Broadcasting in Afghanistan [Installation of Telefunken High-Power Loudspeaker Equipments to receive from the 15 kW Kabul Station].—(*Zeitschr. V.D.I.*, 26th July 1941, Vol. 85, No. 30, p. 662.)

3161. Broadcasting as a Weapon: Need for "Fierce and Stubborn Resistance" [Editorial on Speech in House of Commons].—Plugge. (*Wireless World*, Sept. 1941, Vol. 47, No. 9, p. 223.)

3162. Lifeboat Wireless: Automatic SOS Transmitter [and Receiver].—Ministry of War Transport. (*Wireless World*, Sept. 1941, Vol. 47, No. 9, p. 235.) *Cf.* "Prize Inventions," *ibid.*, p. 236.

GENERAL PHYSICAL ARTICLES

3163. On a Magneto-Acoustic Effect [Theoretical Considerations predicting that Velocity of Sound in Liquids will be changed by Magnetic Field (by 3–4% in case of Nitrobenzene)].—Rao: Sibaiya. (*Phys. Review*, 15th July 1941, Vol. 60, No. 2, pp. 156–157.) Sibaiya is about to verify the conclusions experimentally.

3164. On the Attendant Phenomena of the Inverse Stark Effect (Electrical Double Refraction) [Experimental Investigation using Atomic Ray as Absorbing Layer: Field Strengths of 250 kV/cm].—Gabler. (*Physik. Zeitschr.*, March 1941, Vol. 42, No. 4/5, pp. 67–72.)

3165. A Radiant Energy Theory of the Absorption of Primary X-Rays, Ionisation and Photoelectron Emission, *and* On a Modification of Planck's Quantum Theory with Special Reference to an Explanation of His Oscillators.—Cook. (*Phys. Review*, 15th July 1941, Vol. 60, No. 2, p. 158: p. 164: summaries only.)

3166. The Influence of Radiation Damping on the Scattering of Light and Mesons by Free Particles, *and* The Quantum Theory of Radiation Damping.—Heitler: Wilson. (*Proc. Cambridge Phil. Soc.*, July 1941, Vol. 37, Part 3, pp. 291–300: pp. 301–316.)

MISCELLANEOUS

3167. A New Calculus for the Treatment of Optical Systems.—Clark Jones, Hurwitz. (*See* 2992.)

3168. Perturbation of Boundary Conditions [Method applicable to Room Acoustics, Electromagnetic Radiation Problems (Resonators of Rhumbatron Type, etc.), Electronic Wave Functions for Metals, etc.].—Feshbach & Clogston. (*Phys. Review*, 15th Jan. 1941, Vol. 59, No. 2, pp. 189–194.)

3169. The Nature, Meaning, and Purpose of the Laplace Transformation.—Schulz. (*See* 3008.)

3170. Optimum Design of Physical Apparatus [Mathematical Theory illustrated by Examples from Statistics, Television, etc.].—Spencer. (*Phys. Review*, 15th July 1941, Vol. 60, No. 2, p. 172: summary only.)

3171. "Praktische Nomographie" [including Nomograms for Any Number of Variables: Book Review].—Diercks & Euler. (*Zeitschr. f. Instr:kunde*, June 1941, Vol. 61, No. 6, pp. 199–200.) For Allcock & Jones's book *see* 3810 of 1939.

3172. "Tafeln elementarer Funktionen" [in Physics & Engineering: Book Review].—Emde. (*Schweizer Arch. f. angew. Wiss. u. Tech.*, April 1941, Vol. 7, No. 4, p. 120.)

3173. "Argument of Blood" and "Science in Chains" [Rise & Decay of Science in Germany: Review of Two *Macmillan War Pamphlets*].—Huxley: Gregory. (*Nature*, 26th July 1941, Vol. 148, pp. 91–93.)

3174. The Office of Scientific Research and Development [and Its Functions & Duties].—(*Science*, 11th July 1941, Vol. 94, p. 33.)

3175. War Inventions [Address on the Inventions Section of Ministry of Supply].—Gough. (*Engineer*, 1st Aug. 1941, Vol. 172, pp. 68–69 and 71.) For Editorial *see* pp. 72–73.

3176. Central Commission for the Examination of Inventions [Figures for 1st April/30th October 1940: Total 1609, including 48 for "Perpetual Motion": 114 Favourable Verdicts: etc.].—(*La Ricerca Scient.*, Nov. 1940, Vol. 11, No. 11, p. 919.)

3177. THE PLACE IN INDUSTRY OF THE SEVERELY DISABLED WORKER.—Cunit. (*E.T.Z.*, 30th April 1941, Vol. 62, No. 18, pp. 422–423.) A short note, with special reference to the electrical industry, prompted by a recently published volume (with 360 examples) for the heavy industries.

3178. INCOMPLETE FILES OF CURRENT PERIODICALS IN AMERICAN LIBRARIES, *and* THE CONTINUITY OF THE SCIENTIFIC RECORD [and the Use of Microfilms].—Brown: Davis. (*Science*, 23rd May 1941, Vol. 93, p. 496.) Prompted by a letter by Mudd.

3179. A NEW BRITISH SCIENTIFIC JOURNAL [Quarterly Journal, with Versions in at least Three Foreign Languages: to appear in Autumn]. —Imperial Chemical Industries. (*Nature*, 30th Aug. 1941, Vol. 148, p. 252.)

3180. SUMMARY OF WORK DEALT WITH BY THE NATIONAL COMMITTEE FOR RADIO TECHNIQUE AND TELECOMMUNICATIONS: *and* BY THE "G. MARCONI" CENTRE AND THE "GALILEO FERRARIS" INSTITUTE. — (*La Ricerca Scient.*, Sept. 1940, Vol. 11, No. 9, pp. 666–668: Oct. 1940, No. 10, pp. 799–802 & 802–802.)

3181. RESEARCH IN ELECTRICAL ENGINEERING [Editorial].—(*Engineering*, 12th Sept. 1941, Vol. 152, pp. 211–212.)

3182. MAKING GREATER USE OF INVENTION.— Macdonald. (*Engineer*, 29th Aug. 1941, Vol. 172, pp. 135–137.)

3183. WHAT KINDS OF LIGHT ATTRACT NIGHT-FLYING INSECTS MOST? LEAST?—Porter. (*Gen. Elec. Review*, June 1941, Vol. 44, No. 6, pp. 310–313.)

3184. A PHOTOMETER FOR REFLECTED LIGHT, USING IRIS DIAPHRAGM WITH MICROMETER ADJUSTMENT AND OPPOSED PHOTOCELLS AS ZERO INDICATOR.—Caglioti & others. (*La Ricerca Scient.*, Nov. 1940, Vol. 11, No. 11, pp. 852–855.)

3185. A NEW PHOTOMETER FOR ASTRONOMICAL WORK [using Two Barrier-Layer Photocells]. —Link. (*Zeitschr. f. Instr:kunde*, June 1941, Vol. 61, No. 6, pp. 194–195: summary only.)

3186. SIMPLE PHOTOELECTRIC BRIGHTNESS METER [for the Printing Industry], *and* THE COMPARATOR-DENSITOMETER.—Poulter: Dietert. (*Journ. of Scient. Instr.*, Aug. 1941, Vol. 18, No. 8, pp. 166–167: pp. 169–170.)

3187. A DIRECT-READING MICROPHOTOMETER [for Spectrographic Analysis: using Weston Photronic Cell & Galvanometer].—Langstroth & others. (*Canadian Journ. of Res.*, July 1941, Vol. 19, No. 7, Sec. A, pp. 103–108.)

3188. LIGHT-BEAM POINTER RECORDS DIRECTLY WITH PEN BY TWIN-PHOTOCELL ARRANGEMENT MOUNTED ON CARRIAGE CARRYING PEN.—Pompeo & Penther. (*Sci. News Letter*, 28th June 1941, Vol. 39, No. 26, p. 406.)

3189. FOUR-PHOTOCELL ELECTRIC EYE FOR RECORDING HIGH JUMPS.—General Electric. (*Sci. News Letter*, 5th July 1941, Vol. 40, No. 1, pp. 6 & 7.)

3190. COMMENT ON "A FOOTCANDLE-HOUR INTEGRATOR FOR DAYLIGHT" [Disagreement with Statement that "No Phototube or other Photoelectric Device accurately reproduces Spectral Sensitivity of Eye": the Weston Photronic Cell with Viscor Filter: Reply]. Varden: Taylor. (*Journ. Opt. Soc. Am.*, July 1941, Vol. 31, No. 7, pp. 507–508.) *See* 1568 of May.

3191. PHOTOELECTRIC CELLS FOR THE VISIBLE SPECTRAL RANGE ["Alloy" Cathodes with "Surprisingly High" Sensitivities].—Görlich. (*See* 3093.)

3192. NEW DEW-POINT APPARATUS AS A MEANS OF FUEL ECONOMY IN INDUSTRIAL DRYING PLANTS [for Textiles, Paper, etc: with Photocell & Relay Indication].—Kobel. (*Schweizer Arch. f. angew. Wiss. u. Tech.*, April 1941, Vol. 7, No. 4, pp. 112–114.)

3193. ELECTRON-CURRENT AMPLIFICATION IN PHOTOCELLS BY COMPENSATION OF THE SPACE CHARGE [leading to a Sensitive Photo-Relay]. —Goncharski. (*See* 3092.)

3194. PHOTOELECTRIC APPARATUS FOR MEASUREMENT OF STRAINS IN TRANSPARENT MODELS BY MEANS OF THE TYNDALL EFFECT [New Photoelastic Method].—Menges. (*Zeitschr. V.D.I.*, 19th July 1941, Vol. 85, No. 29, p. 645: summary only.)

3195. COMPENSATING INSTRUMENTS IN TEMPERATURE MEASURING AND CONTROL TECHNIQUE [in the Preparation and After-Treatment of High-Quality Materials: Survey of Commercial Instruments, including Use of Photoelectric Control].—Hunsinger. (*E.T.Z.*, 22nd May 1941, Vol. 62, No. 21, pp. 481–486.)

3196. POTENTIOMETER TYPE OF OPTICAL PYROMETER [for Steel Mills, etc.].—Leeds & Northrup. (*See* 3064.)

3197. EXPERIMENTS ON THE OBTAINING OF A SPECTRUM WITH UNIFORM ENERGY DISTRIBUTION.—Lau & Theissing. (*Physik. Zeitschr.*, March 1941, Vol. 42, No. 4/5, pp. 61–63.)

3198. INCENDIARY-BOMB DETECTOR [using "Radiovisor" Selenium Cells].—(*Engineering*, 5th Sept. 1941, Vol. 152, p. 196: *Electrician*, 19th Sept. 1941, Vol. 127, p. 165.)

3199. INSTRUMENT FOR MEASURING THE RATE OF PENETRATION OF OIL AND OTHER LIQUIDS INTO PAPER.—Poulter. (*Journ. of Scient. Instr.*, Sept. 1941, Vol. 18, No. 9, pp. 188–190.)

3200. AUTOMATIC SPEED CONTROL FOR THE AIR-DRIVEN ULTRACENTRIFUGE [Combination of Stroboscopic & Photoelectric Technique].— Rothen. (*Review Scient. Instr.*, July 1941, Vol. 12, No. 7, pp. 355–357.) Constancy within less than one revolution per second.

3201. G.E. Stroboscope System for Accurate Inspection of Printed Materials at Speeds up to 450 Yards/Minute.—(*Gen. Elec. Review,* June 1941, Vol. 44, No. 6, pp. 349–350.)

3202. Measurements on Mercury-Vapour Surge Discharges at High Pressures [for Extremely Brilliant Flashes for Projection of Continuously Running Films, for Stroboscopy, etc: Special Condenser-Discharge Circuit & Special H.P. Mercury Lamp].—Rompe & Schulz. (*Physik. Zeitschr.*, April 1941, Vol. 42, No. 6, pp. 105–110 and Plate.) *Cf.* Ewest, 798 of 1940. The special lamp now described differs only slightly from that used in the AEG stroboscope, 1704 of 1940.

3203. High-Speed Photography and Its Application to Industrial Problems [Survey].—Eyles. (*Journ. of Scient. Instr.*, Sept. 1941, Vol. 18, No. 9, pp. 175–184.) From the Kodak laboratories.

3204. Superconducting Films as Radiometric Receivers [Infra-Red Beam of 2×10^{-4} erg/sec. gives Galvanometer Deflection of 7 mm].—Andrews & others. (*Phys. Review,* 15th June 1941, Vol. 59, No. 12, pp. 1045–1046.)

"It appears that the ratio of potential drop to radiant energy input is several orders of magnitude higher than in the other methods for measuring radiation in the infra-red region . . ."

3205. Study of Atmospheric Absorption and Emission in the Infra-Red Spectrum.—Strong. (*Journ. Franklin Inst.*, July 1941, Vol. 232, No. 1, pp. 1–22.) For other recent work by the same writer *see* 1152 & 3299 of 1940 and 1297 of May.

3206. Optics of Atmospheric Haze [Theory & Experiment].—Hulburt : Byram. (*See* 2961, above.)

3207. Device for the Observation or Illumination of Objects Not Directly Visible, particularly in Cavities such as Body Cavities [Bundle of Flexible Transparent Fibres each coated with Reflecting Layer].—Rathsmann. (*Zeitschr. f. Instr:kunde,* June 1941, Vol. 61, No. 6, pp. 187–188.) *Cf.* 2171 of 1939.

3208. Radio-Frequency Probe for detecting Metallic Foreign Bodies [Shell-Splinters in Wounds, etc.].—Siemens. (*Wireless World,* Sept. 1941, Vol. 47, No. 9, p. 235.) From *The Lancet.*

3209. Electrosurgery : Radio Technique in the Operating Theatre.—Lay. (*Wireless World,* Sept. & Oct. 1941, Vol. 47, Nos. 9 & 10, pp. 231–233 & 256–257.)

3210. The Meter X : a Portable Direct-Reading X-Ray Intensity Meter.—Zucker & Sampson. (*ASTM Bulletin,* Aug. 1941, No. 111, pp. 41–43.) Sensitivity seven ten-thousandths of a roentgen per minute per mm deflection.

3211. The Calculation of the Field Distribution in a System of Concentric Cylinders of Complex Conductivity traversed by Ultra-High Frequencies.—Stachowiack. (*Ann. der Physik,* 4th May 1941, Vol. 39, No. 5, pp. 403–408.)

It is shown that the theoretical extension of Krasny-Ergen's treatment of a homogeneous cylinder embedded in a medium (3585 of 1937) can be carried out analytically for a laminated cylinder, and allows conclusions to be drawn of practical importance. It is found that the field distribution in the surrounding space (muscular system) is about the same for a laminated cylinder (tubular bones) as for a solid cylinder. The energy absorption in the bone marrow is relatively large owing to the heightened internal field strength. Such calculations as a rule are seriously complicated by the fact that not only the macroscopic structure of the various tissues but also their microstructure is involved : in which case actual measurement is the only solution—either by direct heat measurements such as Steinhäuser's or by electrolytic-trough technique such as that dealt with in 2709/10 of October.

3212. Dielectric Behaviour of Colloidal Systems [Animal Liver Substance, for Wavelengths 300–10 000 m].—Schaefer & Stachowiack. (*Sci. Abstracts,* Sec. A, July 1941, Vol. 44, No. 523, p. 168.)

3213. Electrical Bombardment of Biological Materials.—Morningstar & others. (*See* 3124.)

3214. Dependence of the Biological Effect of Radiation on Intensity and Wavelength [Determination of Lethal Dose for Chick Embryos : Gamma and Medium & Soft X-Rays].—Lea. (*Sci. Abstracts,* Sec. A, July 1941, Vol. 44, No. 523, p. 204.)

3215. The Velocity of Propagation of the Electric Impulse along the Organs of the Electric Eel [up to 1000 m/sec.].—Rosenblith & Cox. (*Phys. Review,* 15th Jan. 1941, Vol. 59, No. 2, p. 219 : summary only.)

3216. An Electron-Microscopic Investigation of the Structure of Reflection-Reducing Films, and the Choice of Thickness for Such Films.—von Ardenne. (*Zeitschr. f. angew. Photographie,* 1941.) Referred to as in the press, in the paper dealt with in 3128, above.

3217. Measurement of Cathode Emission by Use of the Electron Microscope [Photographic Intensity-Measurement Technique].—Fox & Bailey. (*See* 3060.)

3218. Total Atomic Scattering Cross Sections for Fast Electrons [in connection with Marton's Suggestion (2931 of October) to determine Thicknesses of Electron-Microscope Objects].—Schiff : Marton. (*Phys. Review,* 15th July 1941, Vol. 60, No. 2, p. 174 : summary only.)